WSRC-IM-91-116-0
Revision 12

DWPF WASTE FORM COMPLIANCE PLAN (U)

September 2018

J. R. Cantrell
DWPF Facility Manager

Savannah River Remediation
Savannah River Site
Aiken, SC 29808

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO.DEAC09-09SR22505

DWPF WASTE FORM COMPLIANCE PLAN

REVISION PAGE

The following is a summary of the major changes made to the Waste Form Compliance Plan.

Revision 12, September 2018

Part	Item	Revisions
2	100	Updated discussion and Figure 2.100.1 to be inclusive of glycolic acid flowsheet.
3 3 3 3 5 App	200 400 500 800 850 1.200.1	Updated the listed WCP sections (including figures) to reflect that, beginning with Sludge Batch 9, DWPF glass pour stream samples will be collected and archived at SRNL but no longer routinely analyzed for inclusion in the Production Records. Additionally, in WCP Section 3/Part 400 and Appendix 1.200.1, clarified that for macrobatches analyzed after 2015, the initial index year for radionuclide reporting will be the year of radionuclide analysis and not 2015. Added new reference SRR-WSE-218-00020. Also, in WCP Section 3/Part 500, updated discussion to remove glass fabrication and performance of the PCT on the sludge batch qualification sample.
5	400	Corrected smear pad surface area and updated Figure 5.400.1.

Revision 11, June 2016 (Incorporated X-DCF-S-00199 and M-DCF-S-02907)

Part	Item	Revisions
2	100	Added discussion related to double stacking canisters in GWSB#1. Also, clarified discussion that natural convection is relied upon in both GWSBs for canister cooling. Updated Figures 2.100.1 and 2.100.2.
3	600	Added discussion related to double stacking canisters in GWSB#1 in relation to the 400°C temperature limit. Also, clarified discussion that natural convection is relied upon in both GWSBs for canister cooling per X-DCF-S-00199. Added ASTM E1356 standard.
4	100	Incorporated M-DCF-S-02907 (Canister Nozzle Forging ASTM Standard).
5	650	Added discussion related to double stacking canisters and its non-impact on the subcriticality specification.

Revision 10, March 2014

Part	Item	Revisions
4	100	Clarified that canisters with material specifications out of range will be identified as nonconforming vs. not acceptable for use.
4	400	Clarified that canisters with dimensions out of range will be identified as nonconforming vs. not acceptable for use.

Revision 9, June 2012

Part	Item	Revisions
3	200	Removed specificity of sampling feed material with Hydragard valve.

Revision 8, March 2006 (Incorporated X-DCF-S-00191 and X-DCF-S-00193)

Part	Item	Revisions
1	300	General: In each Item and Part listed, references to precipitate batches and PHA were replaced with salt effluent batches, where applicable.
2	100	
3	100	General: Updated references to canister storage facilities to include multiple Glass Waste Storage Buildings. Also incorporated X-DCF-S-00191 and X-DCF-S-00193.
3	200	
3	300	
3	400	
3	500	
3	600	
5	450	
5	550	
5	650	
App	1.200.1	
App	1.200.2	
App	1.200.3	

Revision 7, May 2003

Part	Item	Revisions
1	300	Removed reference to sampling MFT for reporting purposes.
3	200	Removed references to MFT sampling and clarified frequency of pour stream sampling.
3	400	Removed discussion concerning direct measurement of radionuclides at DWPF for reporting purposes and clarified frequency of pour stream sampling.
3	500	Clarified frequency of pour stream sampling.
3	800	Removed discussion concerning direct measurement of radionuclides at DWPF for reporting purposes and clarified frequency of pour stream sampling.
4	200	Removed discussion of final weld inspection.
5	850	Clarified frequency of pour stream sampling.
App 1.200.1		Clarified frequency of pour stream sampling.

Revision 6, September 1999 (Incorporated M-DCF-S-01535)

Part	Item	Revisions
1	100	Revised organization titles and references.
1	200	Deleted FA-20 write-up.
1	300	Deleted "QAPD" acronym and "DWPF Batches" figure. Revised definitions to reflect current status of sludge and precipitate processing.
2	100	Updated description to reflect state of precipitate processing. Modified "canister filling" write-up.
3	100	Deleted reference to New Production Reactor. Added Part 2/Item 100 flag for precipitate processing status.
3	200	Revised the sampling and analytical sections to include the lab insert and alternate analytical methods. Removed unnecessary detail (including one table and two figures). Deleted term "periodically" from glass sampling discussion. Added Part 2/Item 100 flag for precipitate processing status.
3	300	Removed reference to outdated organization. Added Part 2/Item 100 flag for precipitate processing status.
3	400	Deleted unnecessary detail (including two tables). Deleted term "periodically" from glass sampling discussion. Added Part 2/Item 100 flag for precipitate processing status.
3	500	Revised the GPCP section to include the use of the lab insert method. Removed unnecessary detail (including two figures). Deleted term "periodically" from glass sampling discussion. Added Part 2/Item 100 flag for precipitate processing status.
3	600	Clarified determination of "end of initial cooldown".
3	700	Incorporated revised WAPS requirement.
3	800	Added new section to address WAPS 1.6 (new).
4	100	Corrected table numbering. Clarified information in tables. Modified text to state that canister procurement specification is referenced, not included, in WQR.

4	200	Incorporated revised WAPS req. Revised text to reflect reduction of testing and inspections in the DWPF canister procurement spec as well as revised fabrication method. Removed tolerances and weld plug dimensions from figure.
4	300	Removed tolerances in Figure 4.300.3.
4	400	Incorporated revised WAPS requirement.
5	100	Removed unnecessary detail. Corrected joint leak rate to be consistent with canister procurement specification.
5	150	Incorporated revised WAPS requirement.
5	250	Incorporated revised WAPS requirement.
5	400	Incorporated revised WAPS requirement (relaxation of the specification for removable contamination). Generalized smear paper to smear pad. Removed unnecessary detail (including one figure).
5	450	Added Part 2/Item 100 flag for prec. processing status.
5	500	Deleted discussion related to calorimetric experiments.
5	550	Incorporated revised WAPS requirement. Added Part 2/Item 100 flag for precipitate processing status.
5	650	Incorporated revised WAPS requirement. Added Part 2/Item 100 flag for precipitate processing status.
5	700	Incorporated revised WAPS requirement.
5	750	Incorporated revised WAPS requirement.
5	800	Incorporated revised WAPS requirement. Updated drawing number for canister lifting flange. Removed tolerances from lifting flange geometry figure. Removed unnecessary detail (including a table and a figure).
5	850	Added new section to address WAPS 3.14 (new).
6	100	Incorporated revised WAPS requirement. Revised organization titles and references. Deleted QAPD.
6	200	Revised references (deleted QAPD).
6	300	Revised references (deleted QAPD).

App. 1.100.1	Added WAPS 1.6 and 3.14 to WQR Volume 4.
App. 1.200.1	Incorporated new IAEA WAPS requirements (1.6, 3.14) into the Production Records. Updated organization titles. Modified macro-batch definition and timing of delivery of Production Records. Revised strategy associated with documenting glass sample analyses.
App. 1.200.2	Revised description of monitoring of temperature in GWSB. Revised removable contamination levels. Modified timing of delivery of Storage and Shipping Records.
App. 1.200.3	Deleted FA-20 startup test footnote. Revised GWSB temperature monitoring discussion.

Revision 5, November 1995

Part	Item	Revisions
1	100	Updated DOE organization title.
1	200	Deleted drain valve testing in WP-15 and WP-16. Deleted reference to surface thermocouples. Deleted ref. to weld repair cap. Deleted WP-23. Updated WP-17 description.
2	100	Deleted reference to surface thermocouples. Deleted reference to weld repair cap.
3	100	Changed MnO_2 to MnO.
3	200	Clarified Figure 3.200.1. Updated analytical methods.
3	400	Updated analytical methods.
3	500	Updated figure of glass pour stream sampler.
3	600	Deleted reference to WP-23.
3	700	Updated specification.
4	100	Updated specification. Added text addressing secondary canister.
4	200	Deleted discussion of measuring plug displacement and visual observation of final weld. Deleted reference to welding canisters for ASME qualification testing.
5	100	Updated leak rate sensitivity.
5	150	Updated specification.
5	200	Updated specification.
5	300	Updated specification.
5	350	Clarified glass level reporting. Deleted reference to surface thermocouples. Modified target fill level to 96 inches.
5	400	Updated specification. Clarified smear test Operations.
6	300	Updated specification.

App. 1.100.1	Updated revision number and date.
App. 1.200.1	Deleted reference to surface thermocouples.
App. 1.200.2	Updated revision number and date.
App. 1.200.3	Deleted reference to WP-23 and updated strategies for GWSB evaluations. Clarified description of Waste Qualification Runs.

Revision 4, December 1994 (Incorporated M-DCF-S-00332 and G-DCF-S-00012)

Part	Item	Revisions
1	200	Modified description of testing of glass level detection method.
2	100	Modified description of glass level detection method.
3	200	Modified Figure 3.200.4 to reflect sampler modification.
3	500	Deleted reference to Fe^{2+}/Fe(total) for redox determination.
5	350	Modified compliance method for glass level detection.
5	400	Added detail to logic diagram.
5	800	Changed figure of canister grapple to reflect modifications.
App. 1.200.1		Modified method for reporting glass fill level.
App. 1.200.3		Added detail on testing to be performed during Qualification Runs.

Revision 3, April 1994

Part	Item	Revisions
1	100	Clarified documentation requirements.
1	200	Clarified test plan listing. Added reference to Waste Form Qualification Coordinating Plan.
1	300	Added more detail to glossary.
2	100	Minor changes to process description.
3	200	Added pointer to WQR Volume 2.
3	500	Clarified text describing information to be reported for demonstration of control.
4	200	Added statement that welder will be qualified.
5	100	Clarified use of temporary cover.
5	150	Added statement that DWPF process cannot pressurize the canistered waste form.
5	200	Grammatical correction.
5	250	Grammatical correction.
5	350	Added text on disposition of underfilled canistered waste forms.
6	100	Clarified implementation of quality assurance requirements and organizational responsibilities.
6	200	Added statement that WCP is basis for waste acceptance process items and activities.
6	300	Added “action” plan.
6	400	New section.
App. 1.100.1		Deleted WAPS and added WQR volume listing.
App. 1.200.1		Clarified information to be reported in the Production Records.
App. 1.200.2		Changed shipment date of “2008” to “2015”.

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ITEM TITLE: WASTE ACCEPTANCE PROCESS

The Department of Energy currently has approximately 130 million liters of high-level radioactive waste in storage at the Savannah River Site (SRS). These wastes, which were generated during the production of nuclear materials for defense needs, have been stored as alkaline slurries in large carbon-steel tanks. This mode of storage, begun in the mid-1950's, has proven to be a safe and effective way of isolating the hazardous radionuclides from the environment.

However, while storage of liquid waste has been safe and effective, it has required continuous monitoring and periodic retirement and replacement of waste tanks. In the late 1970's, the Department of Energy recognized that there were significant safety and cost advantages associated with immobilizing the high-level waste in a stable solid form. Several alternative waste forms were evaluated in terms of product quality and reliability of fabrication. This evaluation led to a decision to build the Defense Waste Processing Facility (DWPF) at SRS to immobilize the easily dispersed liquid waste in borosilicate glass. In accordance with the NEPA (National Environmental Policy Act) process, an Environmental Impact Statement was prepared for the facility, as well as an Environmental Assessment of the alternative waste forms, and issuance of a Record of Decision (in December 1982) on the waste form. This Record of Decision was endorsed by the Environmental Protection Agency and several independent review groups. The Nuclear Regulatory Commission (NRC) also reviewed the document and had no objection to the decision.

The Nuclear Waste Policy Act of 1982 mandated that all high-level waste would be sent to a federal repository for disposal. In 1985, the President ratified a decision made by the Secretary of Energy to send defense high-level waste, including the canistered waste forms from the DWPF, to a civilian repository. The Department of Energy, recognizing that start-up of the DWPF would considerably precede licensing of a repository, instituted a Waste Acceptance Process to ensure that these canistered waste forms could be accepted for eventual disposal at a federal repository.

As part of the Waste Acceptance Process, the Department of Energy's Office of Civilian Radioactive Waste Management (OCRWM) created the Waste Acceptance Committee (WAC) which was responsible for defining the requirements which canistered waste forms would have to meet to be accepted for eventual disposal at a federal repository. The WAC, with representatives from the repository projects and the waste form producers, developed preliminary waste acceptance specifications which identified these requirements.

In the early 1990s the Waste Acceptance Process underwent a fundamental change. OCRWM used the preliminary specifications as one of the bases for the Waste Acceptance System Requirements Document.[1] This document required that the Department of Energy’s Office of Environmental Management (the cognizant function within the Department for all of the waste form producers) develop waste form production specifications. The Department of Energy’s Office of Environmental Management has responded to this requirement by producing the Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms (WAPS).[2] These now are the basis for waste form acceptance activities at the DWPF.

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The Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms are divided into five sections dealing with the waste form (borosilicate glass), the canister, the canistered waste form, quality assurance of Waste Acceptance Process activities, and documentation and other requirements. The DWPF is required to document its compliance with the WAPS in the Waste Form Compliance Plan (WCP), the Waste Form Qualification Report (WQR), the Production Records, and the Storage and Shipping Records. These documents shall be maintained as permanent records and provided to OCRWM in accordance with Specification 5.1 of the EM-WAPS.

The Waste Form Compliance Plan (WCP) provides general information about the DWPF process and product, and a detailed description of the methods and programs by which the DWPF will demonstrate compliance with each specification in the WAPS (except WAPS 5.2-5.14). This description includes tests, analysis, and process controls to be performed and records that will be provided as evidence.

The Waste Form Qualification Report (WQR) (see Appendix 1.100.1) is a compilation of the results of those testing and analysis programs identified in the WCP. The common objective of those programs is to confirm the DWPF's ability to produce a product which meets specifications. Parts of the WQR will be used to gain approval for startup of the DWPF, and may be used in licensing of a repository containing DWPF canistered waste forms.

The WQR is being prepared in a phased manner. Initial draft sections, primarily those summarizing research and development activities performed for the DWPF by the Savannah River Technology Center (SRTC), are being issued for review and comment as soon as they are prepared. Before the initiation of radioactive operations, the DWPF will issue a preliminary WQR summarizing all of the information available, including the information from the non-radioactive testing in the DWPF. However, it is anticipated that some parts of the WQR (for example, a report on radionuclide analyses of melter feed) will not be completed until after the start of radioactive operations. Thus, work on the WQR will continue even after facility startup.

The Production Records, and the Storage and Shipping Records, are documents that describe the contents and characteristics of specific individual canistered waste forms and are prepared and maintained by the DWPF. The Production Records will summarize the entire production history of each canistered waste form, including canister fabrication, canister filling with glass, and sealing of the filled canister. The Storage and Shipping Records cover storage of the canistered waste form at SRS, loading into a shipping cask and will include identification of any abnormal events such as thermal excursions which have occurred during storage at SRS. Thus, these two sets of records will be the primary documentary evidence that individual canistered waste forms have satisfied the specifications.

References

1. Office of Civilian Radioactive Waste Management, **Waste Acceptance System Requirements Document**, USDOE Document RW-0351P.

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2. Office of Environmental Management, **Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms**, Revision 2, USDOE Document DOE/EM-0093, December 1996.

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According to the Waste Acceptance Product Specifications, this document, the DWPF Waste Form Compliance Plan (WCP), is to provide a detailed description of the methods by which the DWPF will comply with each specification in the WAPS (except 5.2-5.14). This description includes tests, analysis and process controls to be performed and records that will be provided as evidence. Since the WAPS states that the WCP shall describe the Producer's plan for demonstrating compliance, the compliance actions in the WCP will be discussed in the future tense even though the required waste form testing, analysis, etc. may have already been completed and documented in the Waste Form Qualification Report (WQR).

The overall strategy for complying with the WAPS is to assure the quality of the product by a combination of component specifications (e.g., canister procurement specifications), process controls and programs to identify and disposition nonconforming items. Many of the specifications in the WAPS require that the canister and waste form be well characterized before the DWPF begins production of actual waste forms. The research and development activities related to characterization of the waste form and the canister are described in the WCP. Other specifications address canistered waste forms produced during radioactive operations. The strategy for compliance with these specifications is to demonstrate that the DWPF product will be acceptable over the range of anticipated chemical compositions and operating conditions.

The WCP details the compliance actions which will be carried out by the operating contractor for the Savannah River Site - Westinghouse Savannah River Company. The WCP has been prepared by the DWPF with the assistance of the Savannah River Technology Center (SRTC). The WCP is reviewed and accepted by the DWPF before issue. The WCP is issued and maintained by the DWPF and revised as necessary. The first version of the WCP was prepared in 1986 and has been updated periodically since that time. Since 1990, the WCP has undergone independent technical review by DOE's Waste Acceptance Technical Review Group (TRG). This group, with joint sponsorship and participation by DOE's Offices of Civilian Radioactive Waste Management, and Environmental Management, is responsible for independently assessing the technical adequacy of the WCP and other Waste Acceptance Process documents.

Following this Introduction, Part 2 briefly describes the DWPF process. The remaining parts are organized around four of the sections of the Waste Acceptance Product Specifications: waste form, canister, canistered waste form, and quality assurance. The documentation section of the WAPS is addressed throughout the WCP. Within each part, each specification is addressed as a separate item. For each specification, the statement of requirements from the WAPS is presented first in bold-face type, verbatim. This is followed by sections detailing the compliance strategy, implementation of that strategy, and required documentation.

The compliance strategy section is a general description of the strategy, or management plan, to demonstrate compliance with the particular specification. This is supplemented by a logic diagram which depicts the plan of action to satisfy the specification. The set of activities depicted in the diagrams constitutes the set of Waste Acceptance Process activities for that specification. The intended mode of documentation of the planned activities is indicated on the diagram by the symbols used. A key is provided in Figure 1.200.1. The organization assigned responsibility for completing each task on the diagram is also indicated. The DWPF has overall responsibility for the implementation of the Waste Form Compliance Plan.

The documentation section briefly summarizes how compliance with the specification will be documented. The collection of these documentation sections constitutes a definition of the content of the WQR, the Production Records, and the Storage and Shipping Records. Appendix 1.200.1 contains a description of the content of the Production Records, and Appendix 1.200.2 contains a description of the content of the Storage and Shipping Records.

A plan for a comprehensive test program has been developed, covering all aspects of facility startup. One of the primary objectives of the plan is to demonstrate that the facility will be able to satisfy the WAPS. The testing program, called the DWPF Startup Test Program, requires development of detailed test plans and procedures for each of the activities. The test plans and procedures are reviewed and approved by a Joint Test Group (JTG), who ensure that the tests to be performed will meet requirements, in a technically defensible manner. The Joint Test Group has representatives from the facility's startup, engineering, quality, and production, organizations, as well as SRTC (technical bases).

After performance of each test, the JTG reviews the test results for technical correctness. The tests to be carried out as part of the DWPF Startup Test Program are identified by test plan number in Table 1.200.1. The table highlights and includes a description of those tests which will provide the detailed evidence of the DWPF's ability to comply with the WAPS.[1] These results will be included in the Waste Form Qualification Report.

Those portions of the DWPF Startup Test Program which will be carried out before radioactive operations begin, and which will demonstrate integrated operation of the facility to produce an acceptable product are called the DWPF Qualification Runs. The Qualification Runs will be of great importance for demonstrating compliance, because during this period the control strategies and methods for DWPF operation will be implemented and tested. A summary of DWPF Qualification Runs activities relevant to the Waste Acceptance Process is included as Appendix 1.200.3.

In general, precise identification of some of the activities necessary to demonstrate compliance with a given specification will depend on the results of previous actions. It will be the responsibility of the organization assigned to carry out any task in the WCP to identify further actions for each specification, and to determine whether the results of the task necessitate changes in the compliance strategy (see Part 6, Item 200). DWPF (with SRTC's assistance) will assign responsibilities for these new tasks as they are identified.

Some individual canistered waste forms may not comply with the specifications in every respect. For these cases, DWPF will identify WAPS non-conformances and propose a course of action to allow final disposal. This proposed course of action will be submitted to DOE-Savannah River Field Office (DOE-SR) for review, as outlined in Part 6, Item 300. DOE-SR is responsible for

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development of procedures governing communications with, and review by, other organizations in DOE and/or other government organizations. They will gain the consent of other affected organizations (such as the Office of Civilian Radioactive Waste Management) before approving proposed dispositions of nonconforming canistered waste forms.

It is also anticipated that the WCP may require revision after approval by DOE-SR, for example when the specifications become finalized, or when significant DWPF process changes are made. Revisions will be made as necessary to the appropriate Item of the WCP and submitted to DOE-SR for review, as outlined in Part 6, Item 200. DOE-SR is responsible for development of procedures governing communications with, and review by, other organizations within DOE, and/or other government organizations.

References

1. S.L. Marra, “Waste Form Qualification Coordinating Plan”, WSRC-RP-93-1556, Revision 2, June 1995.

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Table 1.200.1 DWPF Startup Test Program - Test Index Tests which have significant Waste Acceptance Process components are indicated in **boldface.**

Test Plan Number	Test Title
DWPF-FA-01	Shielding Integrity
DWPF-FA-02	HVAC Testing
DWPF-FA-03	Emergency Power Supply Testing
DWPF-FA-04	Process Vessels Erosion/Corrosion Studies
DWPF-FA-05	Melter Erosion Study
DWPF-FA-07	Integrated Distributed Control System Test
DWPF-FA-08	Integrated Operation with Water
DWPF-FA-09	HEME/HEPA Dissolution Test
DWPF-FA-10	Melter Feed Start-up with Simulated Feed
DWPF-FA-11	Melter Start-up and Drain Valve Testing
DWPF-FA-12	**Inner Canister Closure, Repair, & Leak Testing** During this test, the Inner Canister Closure process will be demonstrated, including formation of the seal, testing of the seal, and the process for forming a repair seal.
DWPF-FA-13	**Melter Characterization with Composite Feed** The primary purpose of this test is to flush the melter, in preparation for the start of the Qualification Runs. This test also provides an opportunity to collect data to begin characterization of melter performance.
DWPF-WP-14	**Melter Characterization with Doped Feed** This test, the first of the Qualification Runs, will accomplish two purposes. First, it will provide data which will allow the DWPF to characterize the flow of material through the melter for normal small changes in feed composition. A non-radioactive dopant will be added to the feed and its in-growth in the glass product followed. Second, the results of this test will demonstrate the DWPF's ability to maintain a consistent product during normal small changes in feed composition. This test will also provide canisters for the testing required to meet specifications 2.2, and 3.1-3.6 of the WAPS.
DWPF-WP-15	**Melter Characterization with Low Viscosity Feed**

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This Qualification Runs test will accomplish two purposes. First, it will provide data which will allow the DWPF to characterize the flow of material through the melter for large changes in feed composition, which lead to low glass viscosity and high glass density. A simulated Purex waste will be used as the feed and its in-growth in the glass product followed. Second, the results of this test will demonstrate the DWPF's ability to maintain a consistent product during large changes in feed composition, which lead to low glass viscosity and high glass density. This test will also provide canisters for the testing required to meet specifications 2.2, and 3.1-3.6 of the WAPS.

DWPF-WP-16 **Melter Characterization with High Viscosity Feed**
This Qualification Runs test will accomplish two purposes. First, it will provide data which will allow the DWPF to characterize the flow of material through the melter for large changes in feed composition, which lead to high glass viscosity and low glass density. A simulated HM waste will be used as the feed and its in-growth in the glass product followed. Second, the results of this test will demonstrate the DWPF's ability to maintain a consistent product during large changes in feed composition, which lead to high glass viscosity and low glass density. This test will also provide canisters for the testing required to meet specifications 2.2, and 3.1-3.6 of the WAPS. Also during this test, canister cooling temperatures will be measured for two canisters filled on the melter pour turntable.

DWPF-WP-17 **Melter Characterization with Mercury in Initial Feed**
This test, the last of the Qualification Runs, will accomplish the following purposes. It will provide data which will allow the DWPF to characterize the flow of material through the melter for large changes in feed composition, going from high glass viscosity and low glass density back to a composite type feed. The results of this test will also demonstrate the DWPF's ability to maintain a consistent product during large changes in feed composition, going from high glass viscosity and low glass density back to a composite type feed. The ability to generate the Production Records will also be demonstrated.

DWPF-WP-19 **Remote Process Sampling Test**
During this test, the precision and accuracy of the DWPF sampling and analytical systems for determination of the chemical composition will be characterized.

DWPF-WP-21 **Canister Free Volume**
During this test the infrared level detection system will be tested to demonstrate that the glass fill height can be monitored and controlled.

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DWPF-WP-22 **Canister Free Liquid and Pressure**
Canisters filled throughout the Qualification Runs will be sampled to determine whether they contain any foreign materials (e.g. liquids, explosives, organics) and to determine the internal pressure after canister closure.

DWPF-WP-24 **Canister Welding Parametric Study**
The purpose of this test is to develop the envelope of operating parameters (force, current, time) for the DWPF welder which will produce acceptable welds. A statistical experimental design approach will be used to define an operating window. Welds will be characterized according to their leak rates, burst strengths, and microstructures. This test will also qualify the welding system's ability to routinely produce acceptable welds by operating within the envelope of acceptable operating parameters.

DWPF-VN-25 **Canister Handling & Decontamination Systems**
The amount of material removed by the decontamination process will be determined as part of this test. Use of the canister grapple will also be demonstrated.

DWPF-VN-26 Main Process Cell Crane & Controls

DWPF-VN-27 DWTT & Waste Transfer Facilities

DWPF-VN-28 Chemical Waste Treatment & Catch Tanks

DWPF-FA-29 Cold Chemical Feeds

DWPF-FA-30 Process Vessel Vent System

DWPF-VN-31 **Canister Transport & Storage**
As part of this test, measurements of weights and overall dimensions of filled canisters from several of the Qualification Runs will be performed.

DWPF-VN-32 Melter Electrical Systems

DWPF-FA-33 **Welder Systems**
This test will demonstrate the operability of the DWPF welder system for normal welds.

DWPF-VN-34 Compressed Air Systems

DWPF-FA-35 SRAT Operation

DWPF-FA-36 **SME Operation**
As part of this test, the operability of the SME process will be demonstrated.

DWPF-FA-37 Precipitate Process Operation

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DWPF-FA-38 Off-Gas System Operation

DWPF-WP-39 **Glass Sampling Test**
The melter runs (FA-13, WP-14 through WP-17) will demonstrate the ability of the DWPF to routinely take glass samples from the stream of molten glass entering the canister. The ability of SRTC to characterize those samples for the DWPF will also be demonstrated. A test results report will be written summarizing these activities.

DWPF-VN-40 Process Information Management System

DWPF-VN-41 Fire Detection and Protection Systems

DWPF-FA-42 **Glass Removal from Canister**
This test will demonstrate the ability of the DWPF to remove any glass adhering to the outside of the canister after filling.

DWPF-FA-44 HVAC - FOS, Control, Analytical Facilities and Computer Rooms

DWPF-VN-45 Electrical System Distribution Test

DWPF-FA-46 Interarea Transfer Facilities

DWPF-FA-47 Hydrogen and Ammonia Mitigation Modifications

DWPF-FA-48 S-4620 Fire Protection System

DWPF-VN-49 Radiation Monitoring Systems

DWPF-VN-50 Canyon Equipment Remotability Verification Program

DWPF-FA-63 DWPF Safety Basis Upgrades for DWPF Purge Systems

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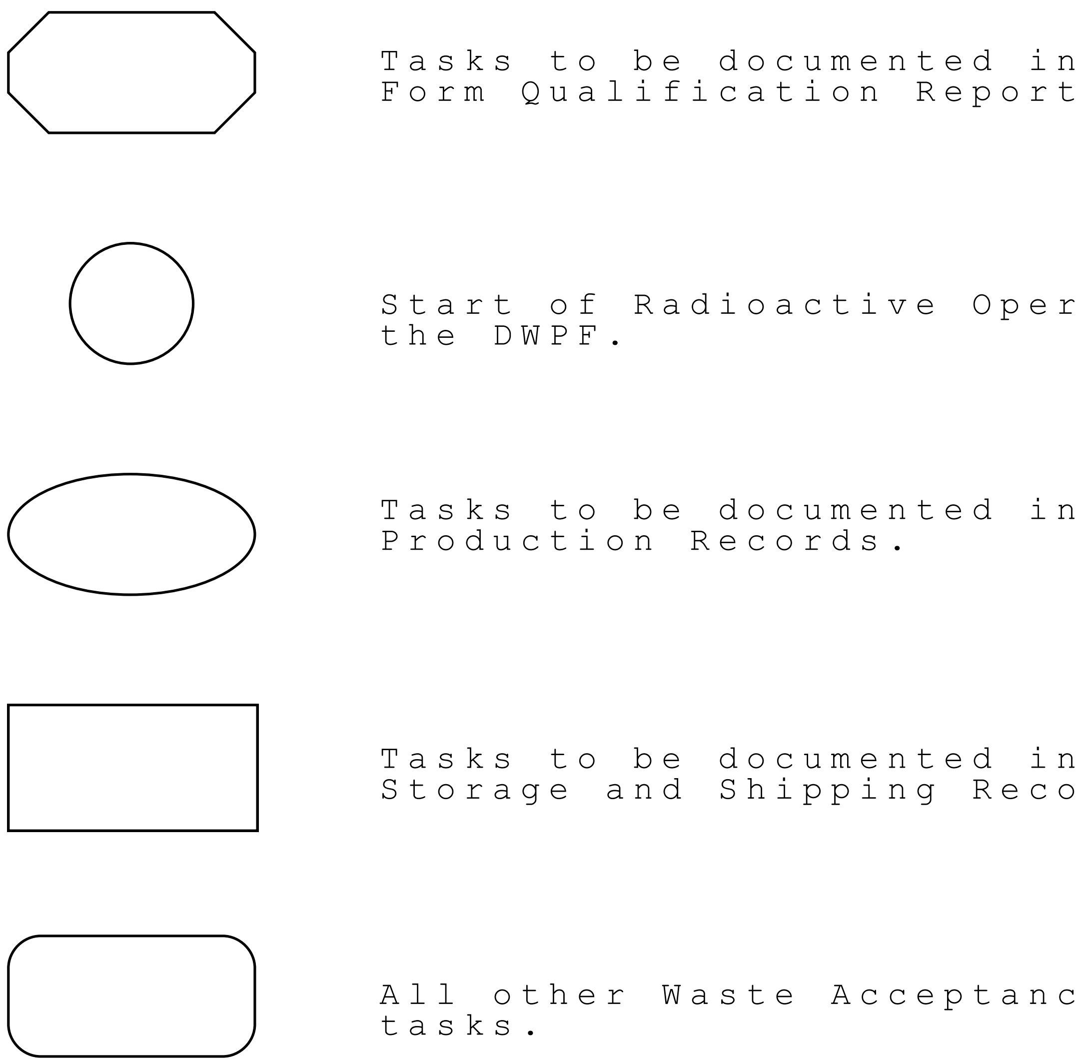
Figure 1.200.1 Symbol key for logic diagrams



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ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

Accuracy

As used in the Waste Form Compliance Plan (WCP), accuracy refers to the ability of a measurement system to reproduce the value of a known standard. The difference between the mean of a number of measurements of a standard, and the accepted value of the measurement for that standard is a measure of the accuracy.

Batches

Process Batch

A portion of the macro-batch that passes through each process vessel; its composition changes because of heels in the tanks. The vitrification process is controlled at the process batch level.

Macro-batch

In the SRS Tank Farm, the feed to the DWPF will remain relatively constant for extended periods of time. The sludge portion of the waste will change every several years, while it has not yet been defined how often the soluble waste will change. The relatively constant feed to the DWPF constitutes a macro-batch.

MFT (Melter Feed Tank) Batch

The contents of the Melter Feed Tank constitute an MFT batch. This includes the material transferred from the SME and the heel that was already in the MFT. Therefore, the composition of the MFT batch may differ slightly from the SME batch and it has a variable volume. One MFT batch will yield an average of six canisters.

Salt Effluent Batch

Salt effluent batches will be a combination of monosodium titanate (MST)/sludge and cesium strip effluent. These batches are expected to remain fairly constant in composition from batch to batch.

Sludge Batch

The sludge is prepared in the Tank Farm for delivery to the DWPF in approximately 400,000-700,000 gallon (1,500,000-2,700,000 L) batches. This sludge batch will supply the DWPF with material for several years.

SME (Slurry Mix Evaporator) Batch

The contents of the Slurry Mix Evaporator (SME) constitute a SME batch. This includes the material transferred from the SRAT as well as the heel remaining in the SME. The SME is the point where DWPF will exercise primary control of the glass product.

PART TITLE: INTRODUCTION

ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

Canister Bowing

Canister bowing is the deviation of the canister from a perfect right cylinder. It is expressed as the variation in the distance from the canister cylinder to a fixed vertical reference line.

Canister Ovality (or cylindricality)

Canister ovality (or cylindricality) is the difference between the maximum diameter and the minimum diameter at a particular canister height.

Control Charting

Control charting is the plotting of data on a continuous basis so that it can be monitored for statistical control purposes.

Defense Waste Processing Facility (DWPF)

The Defense Waste Processing Facility is the facility where waste from the Savannah River Site's Tank Farms is immobilized in borosilicate glass, in preparation for shipment to the repository.

Design-Basis glass

The Design-Basis glass for the DWPF refers to the glass composition assumed for design of the DWPF facility. This composition was used to develop physical, radiochemical and chemical data for design of the DWPF. The Design-Basis glass composition and its set of properties are exemplars of the types of data which will be used to satisfy specifications requiring projections of DWPF glass compositions and properties.

The chemical composition of the Design-Basis glass is based on a nominal mixture of frit, sludge, and PHA. The frit used is the current frit composition. The sludge composition used is a blend of all of the sludges in the SRS Tank Farm; the PHA composition is based on a blend of all of the salt in the Tank Farm. Thus, the Design-Basis glass is often designated as the “Blend” composition.

The radionuclide inventory of the Design-Basis glass is based on a hypothetical scenario for waste generation at SRS. It provides an upper bound for radiogenic properties, such as dose rate and heat generation.

As the DWPF process has developed, the composition and proportions of the frit, sludge, and PHA have changed. These changes have lead to changes in the chemical composition of the Design-Basis glass. For purposes of compliance with the WAPS, the term “Design-Basis glass” will only be used to refer to the composition given in Table 3.100.1.

PART TITLE: INTRODUCTION

ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

DWPF Startup Test Program

The DWPF will carry out a comprehensive program to test all systems in the DWPF which are important to health, safety, environmental protection, and product quality. This program is called the DWPF Startup Test Program. It includes all of the non-radioactive testing in the facility, as well as testing which occurs after the start of radioactive operations. A summary of the DWPF Startup Test Program is included in Table 1.200.1. Those parts of the program most relevant to acceptance of the DWPF product are tested during the Qualification Runs and are summarized in Appendix 1.200.3.

End of canister cooling after filling

Decontamination of the canistered waste form in the Canister Decontamination Cell is not allowed until the canister temperature is below 100°C. This limit is to prevent generation of steam during decontamination using an aqueous frit slurry and provides a convenient definition of the end of cooling after filling.

Environmental Assessment (EA glass)

The EA glass is the typical waste glass composition described in Table 3.1 of Environmental Assessment, Waste Form Selection for SRP High-Level Waste, DOE/EA-0179, July 1982. This document assessed the consequences of using borosilicate glass as the waste form for the DWPF. The EA glass is specified in the WAPS (specification 1.3) as the benchmark for borosilicate waste glass production.

Frit

Glass-forming chemicals will be added to SRS waste in the DWPF in the form of a pre-melted granular glass product. This material, called frit, makes up about 64% of the DWPF glass composition.

Glass Waste Storage Buildings (GWSBs)

After canisters are filled, decontaminated, and welded closed, they will be stored in either GWSB#1 or GWSB#2 until shipment to a repository.

Heel

Whenever a process batch is transferred from one DWPF vessel to another (e.g., from the SME to the MFT), a portion of the process batch remains behind. This remaining portion of the process batch is referred to as a heel.

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ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

HM glass

HM glass for the DWPF refers to the glass composition based on HM or high aluminum waste at SRS. It is a hypothetical glass composition which represents one extreme of the compositions expected to be produced at the DWPF. The HM glass composition represents the upper design limit for glass viscosity.

Inner Canister Closure (ICC)

After the canister is filled with glass, it revolves away (on a turntable) from the melter pour spout, and is temporarily sealed. This temporary seal, which is shrink-fit into the top of the canister, is called the inner canister closure. Its purpose is to prevent water (or other foreign materials) from entering the canister between the filling operation and the time when the canister is welded closed, particularly during decontamination.

Precision

As used in the WCP, precision refers to the ability of a measurement system to reproduce a measurement repeatedly. The standard deviation (or relative standard deviation) is a measure of the precision of a measurement system.

Production Records (PR)

The Production Records are documents that describe the contents and important characteristics of DWPF canistered waste forms. They are specific to individual canistered waste forms. They are not the detailed records of the production of each canistered waste form, but summarize those records and provide the means to retrieve them, if necessary.

Projected glasses

The Waste Acceptance Product Specifications require that the DWPF project the range of glass compositions, and other properties, to be produced in the DWPF. The projected glasses represent both extreme points in that range of compositions (based on possible variations in waste composition, processing equipment performance, and process instrumentation and analysis), and more central points (compositions expected to be actually produced). The projected glasses will be used for qualification testing of the DWPF product.

Purex glass

Purex glass for the DWPF refers to the glass composition based on Purex or high iron waste at SRS. It is a hypothetical glass composition which represents the lower design limit for glass viscosity. It is a possible worst-case composition.

PART TITLE: INTRODUCTION

ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

Qualification Runs (QR)

Before the DWPF begins radioactive operations, the integrated operation of the processing equipment will be extensively tested as part of the DWPF Startup Test Program. During the Qualification Runs portion of the Startup Test Program, the ability of the DWPF process and facility to comply with the Waste Acceptance Product Specifications will be demonstrated. The Qualification Runs are summarized in Appendix 1.200.3.

Rheological Properties

For most fluids, the viscosity of the fluid is the primary rheological property, i.e., is the primary property characterizing fluid flow. These fluids are called Newtonian fluids. However, DWPF melter feed slurries generally act as non-Newtonian, pseudo-plastic (Bingham) fluids. Thus, their flow is characterized by two properties - yield stress and consistency. The yield stress represents the minimum applied force necessary to initiate fluid flow. The consistency is the ratio of the shear stress to the rate of shear.

Storage and Shipping Records

The Storage and Shipping Records are documents which describe the physical attributes of the canistered waste forms. These records summarize the storage history of DWPF canistered waste forms after production, and contain information necessary for shipment. They are specific to individual canistered waste forms.

Sludge

The insoluble portion of SRS waste is referred to as sludge. The sludge consists primarily of hydroxides and hydrous oxides of iron, aluminum, and manganese, and contains essentially all of the long-lived radionuclides in the waste.

Supplier Surveillance Representative

As part of procurement of important items, such as the canister, inspections will be made at the manufacturer's location, to verify that specifications are being met during fabrication. Supplier Surveillance Representatives are the individuals who perform this service for the DWPF.

Tank Farm

Currently, SRS high-level radioactive waste is stored in large (up to 5,000,000 L) carbon-steel tanks on site. The areas containing these tanks are known as the Tank Farms. In addition to storage, the Tank Farms are also used to concentrate and pre-treat the waste prior to transfer of the waste to DWPF.

PART TITLE: INTRODUCTION

ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

Waste Acceptance Process activities

Waste Acceptance Process activities are those activities which will be performed by or for the DWPF to establish the acceptability of DWPF canistered waste forms. The Waste Acceptance Process activities are identified and described in the Waste Form Compliance Plan as part of DWPF's compliance strategy.

Waste type

Several of the specifications require information to be reported on the basis of waste types. For those specifications requiring projections (e.g., WAPS 1.1.1), each sludge batch has been defined to be a waste type. Thus, reporting of projections is done in terms of sludge batches. For those specifications requiring reporting of production information (e.g., WAPS 1.3), each macro-batch has been defined to be a waste type.

PART TITLE: INTRODUCTION

ITEM TITLE: GLOSSARY AND LIST OF ACRONYMS

List of Acronyms

CDC Canister Decontamination Chamber (or Cell)

DOE Department of Energy

DOE-SR DOE-Savannah River Operations; provides oversight of the DWPF

DTT Drain Turntable

DWPF Defense Waste Processing Facility

EA Environmental Assessment

EM DOE-Office of Environmental Management

GPCP Glass Product Control Program

GWSB Glass Waste Storage Building

ICC Inner Canister Closure

ICCS Inner Canister Closure Station

MFT Melter Feed Tank

OCRWM DOE-Office of Civilian Radioactive Waste Management

PCCS Product Composition Control System

PTT Pour Turntable

PCT Product Consistency Test

PHA Precipitate Hydrolysis Aqueous

SME Slurry Mix Evaporator

SRAT Sludge Receipt Adjustment Tank

SRS Savannah River Site

SRNL Savannah River National Laboratory; provides research and development support, WSRC staff of DWPF provides oversight of those SRNL activities affecting product quality

SSR Supplier Surveillance Representative

TCLP Toxicity Characteristic Leaching Procedure

TRG Technical Review Group; provided independent review of waste acceptance documentation for DOE

WAPS Waste Acceptance Product Specifications

WARM Waste Acceptance Reference Manual

WASRD Waste Acceptance System Requirements Document

WCP Waste Form Compliance Plan

WQR Waste Form Qualification Report

WSRC Westinghouse Savannah River Company; operating contractor for the DWPF

WTC Weld Test Cell

PART TITLE: DWPF PROCESS DESCRIPTION

ITEM TITLE: OVERVIEW OF DWPF PROCESS

Introduction

At the Savannah River Site (SRS) in Aiken, South Carolina, the residue of over thirty years of reprocessing of irradiated nuclear fuels for national defense purposes is currently stored in carbon steel tanks. In the Defense Waste Processing Facility (DWPF), the SRS high-level radioactive waste (HLW) will be converted from an alkaline slurry to a durable borosilicate glass. Descriptions of the DWPF and its mission have appeared in the open technical literature (see references at the end of this section). An overview of the DWPF process is presented here, with emphasis on the production of canistered waste forms. A diagram of the baseline waste immobilization process is shown in Figure 2.100.1.

Waste Processing

Waste Processing in Tank Farms

The SRS waste is currently stored on site in carbon steel tanks and exists in three forms: sludge, salt solution, and saltcake (formed through concentration of salt solution). The sludge, comprising approximately 10 vol % of the stored waste, consists primarily of precipitated hydroxides of iron, aluminum, and manganese. The salt (saltcake and salt solution) is largely sodium nitrate, sodium nitrite, sodium aluminate, and sodium hydroxide. The sludge contains most of the radioactivity in the waste, including small amounts of actinides not recovered in the reprocessing plants, and most of the fission products, except for cesium-135 and cesium-137. The salt fraction contains most (ca. 95%) of the radioactive cesium.

The salt effluent that will be sent to the DWPF will include monosodium titanate (MST)/sludge solids as well as cesium strip effluent. The MST/sludge solids are separated via crossflow filtration in an actinide removal process. The resultant soluble cesium-rich salt stream from the filtration is processed using caustic side solvent extraction which generates the cesium strip effluent. After further processing, the concentrated radionuclides are sent to the DWPF to be immobilized in borosilicate glass (see below). The decontaminated salt solution is blended with Portland cement, slag, and flyash in a separate facility for disposal as low-level waste (saltstone process).

Sludge waste is also pretreated in existing waste storage tanks. The object is to dissolve soluble, nonradioactive, ingredients, such as aluminum, so that they may be processed with the salt solution into low-level waste rather than into the more costly high-level waste glass. High-aluminum sludges are leached with excess caustic to dissolve about 75% of the hydrated alumina and reduce the volume of this type of sludge by about 50%. All types of sludge are washed with water to reduce the soluble salt content of the sludge slurry. Current plans are to accumulate about 2500 m^3 of washed sludge slurry, and then to use the batch of sludge slurry as feed to the DWPF. Each batch of sludge, which will be blends of the sludges currently stored in the SRS Tank Farm, will supply the DWPF for two to three years of operation.

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ITEM TITLE: OVERVIEW OF DWPF PROCESS

Salt Effluent Processing

Current plans for treating saltcake and salt solution from the tank farm will involve the DWPF to process MST/sludge solids and cesium-rich strip effluent. These waste streams will be combined with the sludge stream in the DWPF and become immobilized in borosilicate glass.

Sludge Processing and Adjustment

In the DWPF the washed sludge slurry is transferred to the Sludge Receipt and Adjustment Tank (SRAT) where the sludge is treated with nitric acid to neutralize the alkaline waste. Formic acid (or glycolic acid upon replacement of formic acid with glycolic acid) is added to reduce mercury (a minor component of the sludge) to its elemental state. The mercury is steam distilled from the slurry and eventually recovered in reusable, metallic form.

Waste Form Production

Melter Feed Preparation

The slurry is then transferred to the Slurry Mix Evaporator (SME) where premelted and sized borosilicate glass frit is added. Approximately 2/3 of the necessary frit is pumped directly to the SME. The remaining 1/3 of the frit is first used for canister decontamination (frit blasting), and then is added to the SME. The frit-sludge-salt effluent slurry is then concentrated to about 45 wt% total solids by boiling. This mixture is transferred to the Melter Feed Tank (MFT), which delivers feed to the melter.

Melter Operation

Vitrification of SRS waste is accomplished in a slurry-fed, Joule-heated melter (Figure 2.100.2). The feed slurry is introduced from the top of the melter. It forms a crust, or cold cap, on the surface of the melt pool as the water evaporates from the feed slurry, and is removed via the off-gas system. Two pairs of diametrically-opposed electrodes supply electric power directly to the melt. The nominal glass temperature beneath the cold cap is 1150°C, but varies throughout the melter. The cold cap melts from the bottom and forms the borosilicate waste glass matrix. For a nominal pour rate of 100 kg/hr, and a nominal glass melt weight of 6500 kg in the melter, the average residence time in the melter is about 65 hours. The dome of the melter contains four pairs of metal resistance lid heaters that are used to provide the heat for startup, as well as supplemental heat during glass production.

Canister Filling

Glass is normally removed from near the bottom of the DWPF melter through a riser and pour spout (Figure 2.100.2). The canister, on the pour turntable, is connected to the melter by a bellows assembly, which seals the canister-

PART TITLE: DWPF PROCESS DESCRIPTION

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pour spout connection. Pouring is accomplished by drawing a vacuum on the pour spout relative to the melter. Canister filling is monitored by an infrared level detection system. When the desired level of fill in the canister is achieved, pouring is stopped by equalization of the pressure between the melter and the pour spout. After pouring is stopped, venting of the canister to the off-gas system is continued. The canister is then rotated from beneath the pour spout. The canister is then temporarily sealed (ICC) with a tapered plug that shrink-seals as cooling continues, creating a leaktight seal of better than 2 x 10^{-4} atm-cc He/sec.

Canister Decontamination

Frit slurry blasting is used to remove contamination and metal oxides from the canister surface. As the canister rotates through a helical path in an enclosed chamber, jets blast all exposed surfaces with an aqueous slurry of glass frit. After canister decontamination, the used frit slurry (containing the contamination from the canister surface) is sent to the SME for melter feed preparation.

Final Canister Closure

The canister is sealed by upset resistance welding a nominal 12.89 cm diameter plug into the canister nozzle. After canister decontamination and drying, the temporary seal is pushed down in the canister neck, exposing clean metal for a permanent plug weld. The plug, which is slightly larger in diameter than the nozzle bore and has a tapered edge, is centered in the nozzle. The canister is supported by its flange on the welder bottom electrode, then the upper electrode is lowered onto the plug. As a force of 90,000 lbs (400,000 newtons) is applied to the plug, a current of 250,000 amperes is passed through the plug and nozzle. The 40 cm line of contact is heated (but not melted), the plug is forced into the nozzle, and a 1-cm thick, solid state weld is made in 1.5 seconds. The weld produced is sufficiently leaktight to meet specification 2.2 (based on experimental evidence the weld is leaktight to approximately 1 x 10^{-9} atm-cc He/sec, and of comparable strength to the base metal).

Interim Storage

The filled, decontaminated, and sealed canisters are moved by a shielded transport vehicle and stored in the Glass Waste Storage Buildings (GWSBs). In both GWSBs, air is circulated across the canisters' surfaces by natural convection to prevent overheating of the building and to keep the canisters cool. Current plans include the double stacking of canisters in GWSB#1 to allow for additional canister storage.

References

PART TITLE: DWPF PROCESS DESCRIPTION

ITEM TITLE: OVERVIEW OF DWPF PROCESS

1. R. Maher, L. F. Shafranek, J. A. Kelley, and R. W. Zeyfang, "Solidification of the Savannah River Plant High-Level Waste", **American Nuclear Society Trans.**, **39**, p. 228, 1981.

2. M. D. Boersma, "Process Technology for the Vitrification of Defense High-Level Waste at the Savannah River Plant", **American Nuclear Society - Fuel Reprocessing and Waste Management proceedings**, **1**, p. 131-47, 1984.

3. R. G. Baxter, "Design and Construction of the Defense Waste Processing Facility Project at the Savannah River Plant", **Waste Management '86, 2, High-Level Waste**, p. 449, 1986.

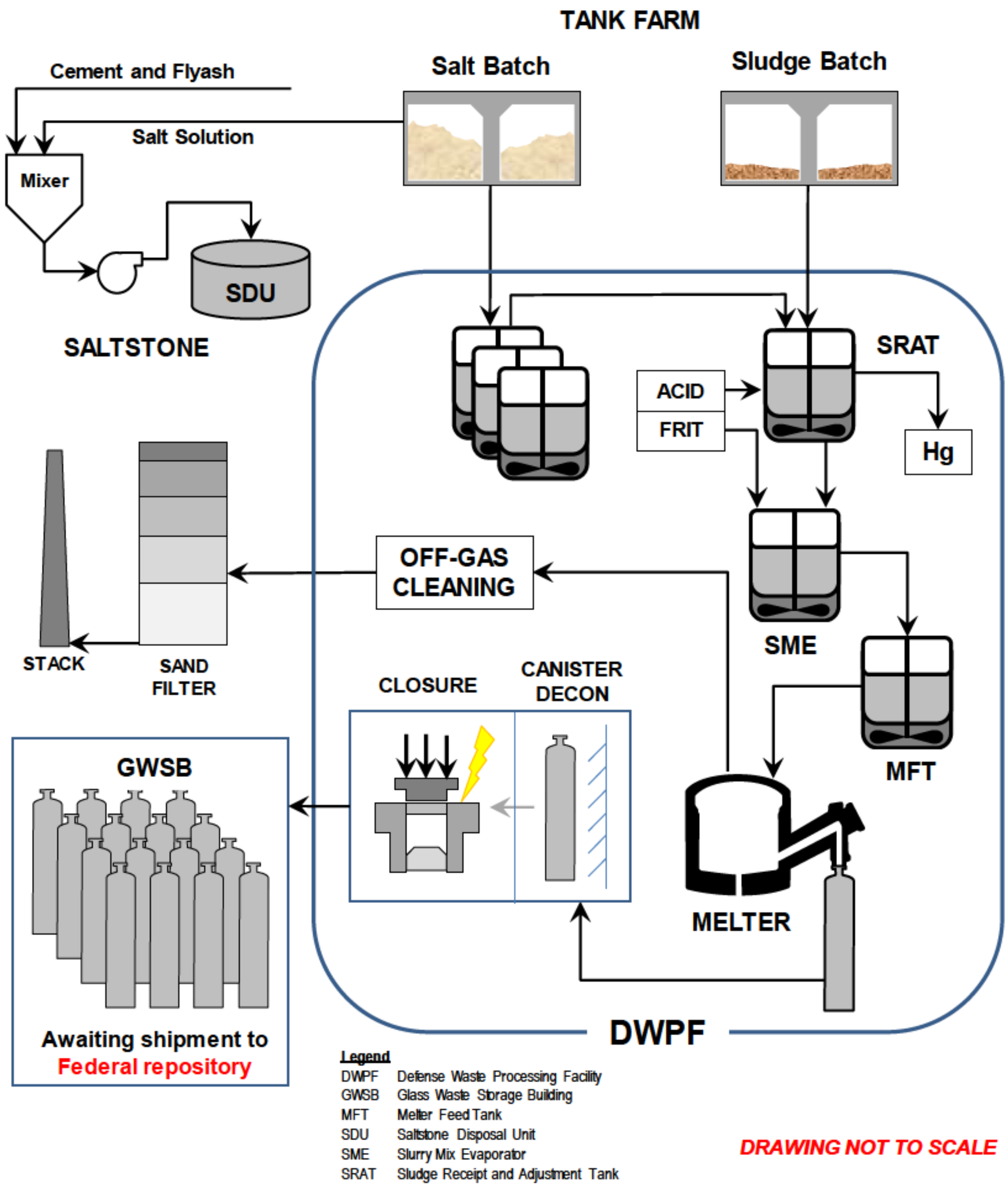
4. R. G. Baxter, **Defense Waste Processing Facility Wasteform and Canister Description**, USDOE Report DP-1606, Revision 2, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 19808 (1988).

5. A. F. Weisman, L. M. Papouchado, J. R. Knight, D. L. McIntosh, "High Level Waste Vitrification at the Savannah River Plant," **Waste Management 88**, **2**, Roy G. Post (ed.), 203-10 (1988).

PART TITLE: DWPF PROCESS DESCRIPTION

ITEM TITLE: OVERVIEW OF DWPF PROCESS

FIGURE 2.100.1 Immobilization of Savannah River Site Waste (baseline process).



PART TITLE: DWPF PROCESS DESCRIPTION

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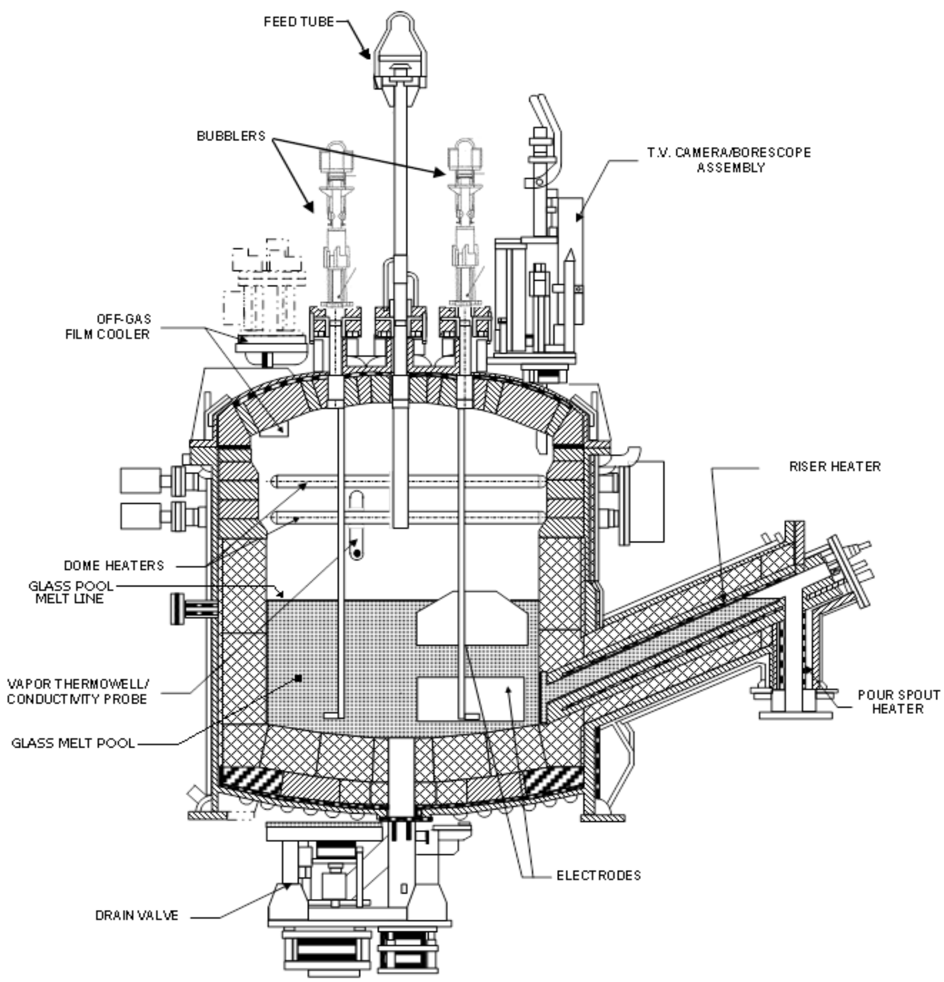
FIGURE 2.100.2 DWPF Melter System



MELTER CHARACTERISTICS

Weight of assembly filled with glass	73,000 kg
Total melter volume	5.5 m^3
Average glass volume	2.5 m^3
Glass height along sidewall	0.86 m
Glass height along centerline	0.95 m
Melter diameter	1.8 m
Pour spout inside diameter	5 cm
Riser angle	25° 30'

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

1.1 CHEMICAL SPECIFICATION

The waste form is borosilicate waste glass.

1.1.1 Chemical Composition Projections

In the WQR, the Producer shall project the chemical composition, identify crystalline phases expected to be present, and project the amount of each crystalline phase, for each waste type. The method to obtain the required data shall be described by the producer in the WCP. The data shall be provided in the WQR. Waste form compositions not available for reporting in the initial WQR shall be included in an addendum to the WQR.

Compliance Strategy

A set of projected glass compositions will be defined, which will span the range of properties of glasses expected to be produced in the DWPF. The projected compositions will be defined based on the compositions of wastes currently stored in the Tank Farms at SRS, anticipated blending schemes for the wastes in the Tank Farm, hypothetical waste compositions, and the expected composition(s) of the glass frit to be used. Among these compositions, a credible "worst case" will also be included. Each sludge batch from the Tank Farm will constitute a waste type for compliance with this specification.

The range of glass compositions will be of a broad nature because of the uncertainties in the assumptions needed to develop the specified projections. These estimates will take into account all of the information available at the time they are made, but will not necessarily reflect the composition of any particular waste forms subsequently produced. However, it is anticipated that the range of properties (processing properties, durability as measured by the Product Consistency Test, crystallization behavior, and waste solubility) of compositions projected as above will encompass those of all glasses produced in the DWPF. If future site processes significantly change so that the composition of the waste would produce a glass whose properties might fall outside the range spanned by the projected compositions, then the composition (and properties) of glass to be made from the new waste will be projected in the same manner as for current waste compositions. The qualification of new compositions is discussed further in Part 3, Items 500 and 600.

Glasses representing each of the projected compositions will be exposed to the range of thermal conditions expected during filling and cooling of the DWPF canister. For each projected composition, the crystalline phases formed will be identified, and their content determined.

Implementation

The plan being followed to satisfy this specification is outlined in Figure 3.100.1. The plan includes the following elements:

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ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

- Identification of the compositions of the waste currently stored in the waste tanks, as distinct waste categories.[1-5]

- Definition of the anticipated blending schemes for waste currently stored.

- Identification of hypothetical waste compositions.

- Specification of the glass frit composition.

- Development of an integrated flowsheet model, which will convert the waste and frit compositions into projected glass compositions.

- Determination of the temperature profile expected for DWPF canisters during filling with glass, and subsequent cooling.

- Application of that thermal profile to the projected glass compositions, identification of the resultant crystalline phases, and determination of the amounts of each.

Current Waste Inventory

Projections of the chemical composition of the existing waste inventory are principally based on chemical analyses of individual samples of the waste stored on site. Nuclear materials production processes, and the histories and methods of waste handling at SRS combine to show that the Tank Farm contains several general categories of waste:

- HM ("Heavy Metal" process) high heat waste sludge.
- HM low heat waste sludge.
- Purex high heat waste sludge.
- Purex low heat waste sludge.
- Zeolite resin.
- Coal and sand.
- Silver salts.
- Supernatant salt solutions (primarily sodium salts), and salt cakes.

In general, the waste sludges in the Tank Farm are primarily blends of HM and Purex wastes. The zeolite, coal and sand, and silver salts in the waste are contained in the sludge in only a few of the tanks. Thus, these are only included in the projected compositions for the specific sludge batches in which they are currently scheduled to be processed. All of the sludge components, except halides, will be included in the projections as oxides (e.g., Fe_2O_3), or as oxygen-containing salts (e.g., phosphates, sulfates). The material fed to the melter from decontamination of the supernatant salt solution will also be included in the projections as oxides or oxygen-bearing salts. For both waste streams, halides will be included as halide salts.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

Waste Blending

Feed to the DWPF will be prepared in the SRS Tank Farms, by SRS Waste Management Operations. The feed preparation steps include sludge washing and aluminum removal. Waste Management Operations has developed a waste blending strategy which is intended to:

- Minimize dose rate in the DWPF, and in the process for disposal of decontaminated salt.
- Empty the oldest tanks as soon as possible.
- Balance waste types in the DWPF feed, to dampen changes in composition.

The waste blending strategy is further constrained by the connections among the waste tanks.

Each sludge batch is assumed to be a "waste type" for purposes of compliance with this specification. Each sludge batch will provide feed to the DWPF for two to three years. The associated salt compositions which will be processed at the same time are used to define the projected glass compositions. In this way, the blending strategy has been used to develop the projected glass compositions.

Hypothetical Waste Compositions

Accurate projection of the chemical composition of future waste is difficult because of possible SRS nuclear materials production processing changes which could affect waste generation. The compositions of wastes to be generated in the future have been estimated based on historical usage of process chemicals, but modified to reflect current practices in the waste generating processes. The extremes of HM sludges and Purex sludges have been used as hypothetical compositions which may represent future waste generation. Three waste compositions have been generated to serve as input for initial composition projections. They are:

- A blend of HM wastes. This waste reflects current reprocessing practices.
- A blend of Purex wastes. This waste reflects current reprocessing practices.
- The DWPF Design-Basis waste (see Part 1, Item 300), designated "Blend."

Each of these is assumed to be a "waste type" for purposes of compliance with the specification.

Frit

On a weight basis, DWPF glass will nominally consist of 64 wt% borosilicate glass frit and 36 wt% oxides from sludge/salt effluents (see Part 2, Item 100). The glass-former composition for the DWPF has been developed so that DWPF waste glass will have similar properties to simulated waste glasses

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

previously developed for sludge-only processing.[6] This has been achieved by modifying the glass frit composition to take into account changes in waste processing. Properties which are controlled through modification of frit composition are chemical durability of the glass, solubility of waste in the glass-former, thermal stability of the glass, and reliability of processing behavior and product properties.[7,8]

Flowsheet Model

An integrated flowsheet computer model was used to develop the material balance for design of the DWPF at SRS.[9,10] This computer model has been modified to incorporate recent modifications of both the DWPF process, and of SRS processes which produce high-level waste. This model has been used to estimate the nominal average compositions of waste glass that will be produced in the DWPF, based on projections of both current and future waste. The model takes into account

- Sludge and salt effluent compositions which are fed to the DWPF.
- The Tank Farm waste blending strategy.
- Reactions in the DWPF which alter the chemistry of the feed streams.
- Available lead time for adjustments to the feed.
- Frit composition.

The reaction chemistry used in the model is based on data obtained in tests using non-radioactive waste simulants. Data from both laboratory and engineering-scale equipment have been incorporated in the model. When possible, these tests have been augmented by laboratory experiments using radioactive waste from the existing inventory.

The model has been used to generate the projected chemical compositions of four waste glasses to be produced from existing high-level waste inventory. These glasses represent the expected compositions to be produced in the DWPF through at least the first ten years of operation. The compositions of these four glasses (Batches 1-4) are shown in Table 3.100.1. Also represented in this table are three hypothetical glass compositions produced from:

- A glass based on the Design-Basis waste (see Part 1, Item 300), designated "Blend."
- A glass based on HM wastes that represents the upper design limit of glass viscosity that will be produced at DWPF.
- A glass based on Purex wastes that represents the lower design limit of glass viscosity that will be processed at DWPF. This glass composition is based on the following assumptions: maximum salt feed rate to the DWPF, minimum sludge feed rate, minimal removal of soluble salts during sludge processing in the Tank Farm, and use of a frit higher in alkali than the frit which will be used initially in the DWPF. Thus, it represents a possible, though unlikely, worst-case composition.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

Crystalline Phases

Prototypic DWPF canisters have been instrumented with thermocouples and filled under both expected conditions and likely process upset conditions. The thermal profile during filling and cooling was recorded. Several canisters were filled to determine the variability in the thermal profile.

Samples of simulated waste glass of each of the projected compositions will be subjected to the thermal conditions determined from the prototypic canisters, both at the surface of the canister (approximating quenched conditions) and along the centerline (probable worst-case conditions). Crystalline phases generated from these heat treatments will be identified, and the amount of each quantified, using scanning electron microscopy and x-ray diffraction.

Qualification of Future Waste Glass Compositions

When future waste compositions are identified, glasses will be formulated for those compositions which will satisfy all of the production-related specifications (e.g., the criterion in Part 3, Item 500). These glasses will also be subjected to the thermal conditions determined from the prototypic canisters as is currently being done for the projected compositions in Table 3.100.1. The results of these studies will be submitted to the repository program as an addendum to the WQR.

Documentation

The Waste Form Qualification Report will detail the development of the projected glass compositions, and the compositions themselves. The expected temperature profiles of canisters during filling and cooling will be provided. The results of exposing samples representative of each projected glass to the expected thermal profile will be reported, including the identity and amount of any crystalline phases formed.

References

1. J. A. Stone, J. A. Kelley, and T. S. McMillan, **Sampling and Analysis of Savannah River Plant High-Level Waste Sludges**, USERDA Report DP-1399, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1976).

2. J. A. Stone, **Separation of SRP Waste Sludges and Supernates**, USERDA Report DP-1441, Revision 1, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1976).

3. R. S. Ondrejcin, **Chemical Composition of Supernates Stored in SRP High-Level Waste Tanks**, USAEC Report DP-1347, Revision 1, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1974).

4. L. W. Gray, M. Y. Donnan, B. Y. Okamoto, **Chemical Characterization of SRP Waste Tank Sludges and Supernates**, USDOE Report DP-1483, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1979).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

5. R. G. Baxter, **Description of Defense Waste Processing Facility Reference Waste Form and Canister**, USDOE Report DP-1606, Revision 1, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1983).

6. P. D. Soper, D. D. Walker, M. J. Plodinec, G. J. Roberts, and L. F. Lightner, "Optimization of Glass Composition for the Vitrification of Nuclear Waste at the Savannah River Plant," **Bull. Am. Cer. Soc., 62**, 1013-8 (1983).

7. M. J. Plodinec, "Vitrification Chemistry and Nuclear Waste," **J. Non-Cryst. Solids, 84**, 206-14 (1986).

8. C. M. Jantzen, "Systems Approach to Nuclear Waste Glass Development," **J. Non-Cryst. Solids, 84**, 215-25 (1986).

9. J. R. Fowler, et al., "Large-Scale Process Simulation - A Case Study, Integrated Waste Processing Flowsheet for the Savannah River Site," USDOE Report WSRC-RP-89-1018, Westinghouse Savannah River Co., Aiken, SC 29802 (1989).

10. **Basic Data Report for the Defense Waste Processing Facility, Revision 139**, USDOE Report WSRC-RP-92-1186 (1992).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

TABLE 3.100.1 Projected DWPF Waste Glass Compositions.

GLASS COMPOSITION (weight %)	CONSTITUENT SLUDGE TYPE						
	Blend[d]	Batch 1	Batch 2	Batch 3	Batch 4	HM	Purex[w]
Al_2O_3	3.97	4.85	4.44	3.24	3.30	7.06	2.88
B_2O_3	7.98	7.66	7.68	7.68	8.07	6.92	10.17
$BaSO_4$	0.27	0.22	0.24	0.26	0.38	0.18	0.29
CaO	0.96	1.16	0.99	0.92	0.82	1.00	1.01
$CaSO_4$	0.08	0.12	0.11	0.10	0.0034	trace	0.12
Cr_2O_3	0.12	0.10	0.12	0.13	0.14	0.085	0.14
Cs_2O	0.12	0.079	0.081	0.079	0.14	0.073	0.080
CuO	0.44	0.40	0.41	0.40	0.46	0.25	0.42
Fe_2O_3	10.37	12.47	10.57	11.12	11.28	7.36	12.69
Group A[a]	0.14	0.10	0.14	0.10	0.20	0.20	0.077
Group B[b]	0.36	0.22	0.44	0.25	0.60	0.89	0.083
K_2O	3.85	3.47	3.49	3.46	3.98	2.13	3.57
Li_2O	4.38	4.40	4.40	4.40	4.31	4.61	3.10
MgO	1.35	1.36	1.35	1.35	1.38	1.45	1.33
MnO	2.02	2.05	1.62	1.81	3.06	2.07	1.98
Na_2O	8.70	8.58	8.58	8.48	8.85	8.15	12.09
Na_2SO_4	0.10	0.10	0.12	0.095	0.13	0.14	0.12
NaCl	0.19	0.31	0.23	0.22	0.089	0.092	0.26
NiO	0.88	0.74	0.89	1.06	1.08	0.40	1.21
SiO_2	50.01	49.61	50.00	49.81	49.09	54.26	44.39
ThO_2	0.19	0.36	0.62	0.76	0.24	0.55	0.011
TiO_2	0.89	0.65	0.66	0.65	1.01	0.55	0.64
U_3O_8	2.13	0.53	2.29	3.14	0.78	1.01	2.88
TOTAL[z]	**99.50**	**99.54**	**99.47**	**99.52**	**99.39**	**99.43**	**99.54**

[a] Group A: isotopes of Tc, Se, Te, Rb, Mo.

[b] Group B: isotopes of Ag, Cd, Cr, Pd, Tl, La, Ce, Pr, Pm, Nd, Sm, Tb, Sn, Sb, Co, Zr, Nb, Eu, Np, Am, Cm.

[d] The "Blend" is the current DWPF Design-Basis glass (see the Glossary - Part 1, Item 300).

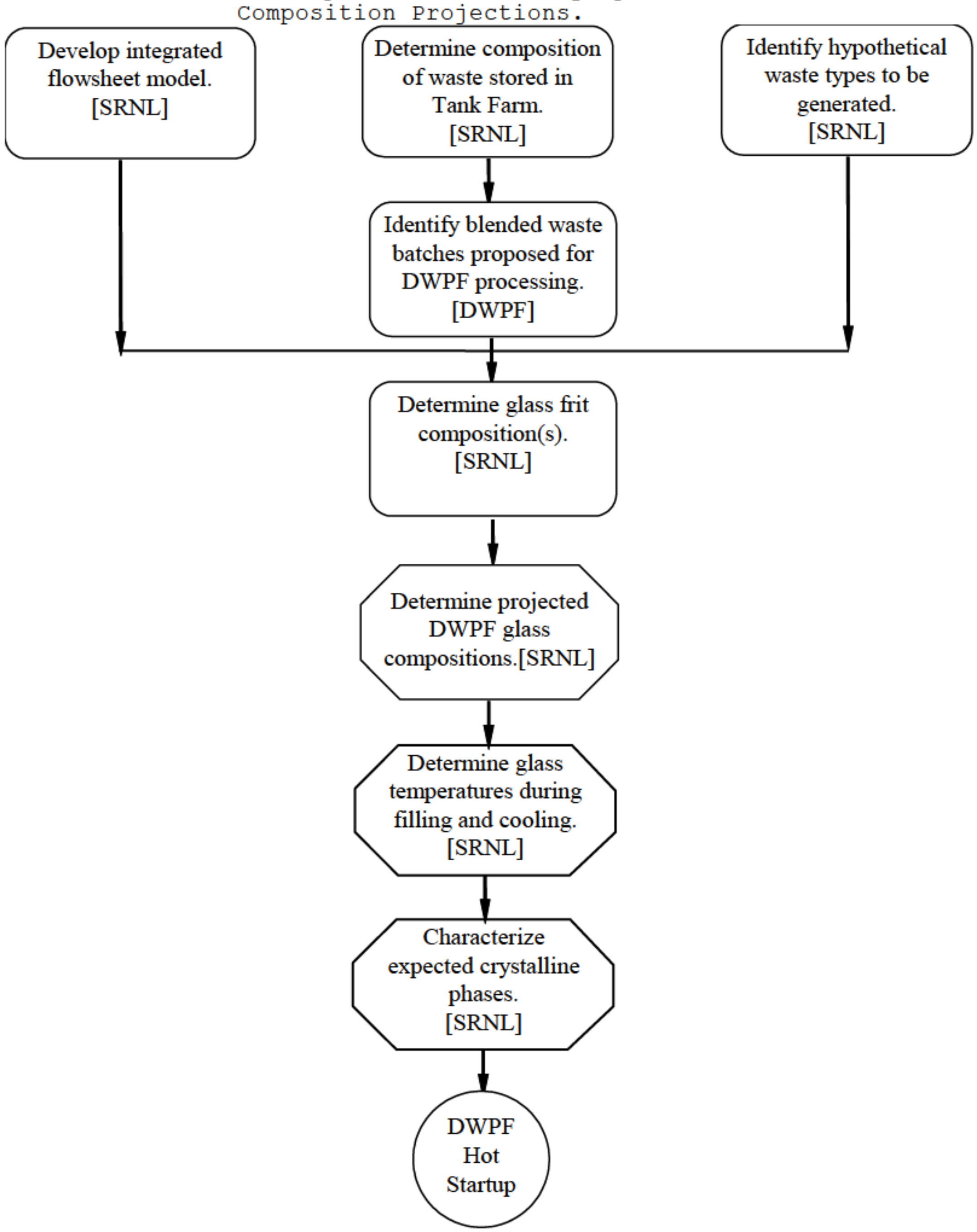
[w] The "Purex" glass is a possible "worst-case" composition.

[z] The Minor components constitute the difference between indicated total and 100%.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

FIGURE 3.100.1 Tasks planned to satisfy Specification 1.1.1 Chemical Composition Projections.



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

1.1.2 Chemical Composition During Production

In the Production Records, the Producer shall report the oxide composition of the waste form. The reported composition shall include all elements, excluding oxygen, present in concentrations greater than 0.5 percent by weight of the glass, for each waste type. The Producer shall describe the method to be used for compliance in the WCP. An estimate of the error of the reported composition and the basis for the estimate shall be reported in the WQR.

Compliance Strategy

The DWPF's strategy for determining the chemical composition of DWPF glass during production (shown in Figure 3.200.1) is based on the relatively constant nature of the sludge feed to the DWPF over the life of each Tank Farm sludge batch, and of the salt effluent feed to the DWPF over the life of each Tank Farm salt effluent batch. Thus, for purposes of compliance with the specification, a macro-batch (see Part 1, Item 300) constitutes a waste type.

Samples from each Tank Farm sludge and salt batch (which together constitute the macro-batch) will be analyzed by SRNL to identify the elements which must be reported for compliance purposes (those present in the glass at > 0.5 wt%). This will be done by identifying all elements present in either the sludge or the salt effluent at greater than 1 wt% which would survive vitrification (see Table 3.200.1). While the representativeness of individual Tank Farm samples cannot be demonstrated, SRS's experience with analyses of samples from the Tank Farm indicates that the range of analytical results for samples from a single tank is less than 30% for major elements. Thus, by choosing a conservative value based on Tank Farm sample analyses, the DWPF is assured of reporting all major species.

During processing of each macro-batch in the DWPF, the DWPF laboratory will analyze samples from each process batch in the SME (see Part 1, Item 300) to determine the actual content of the reportable elements identified from the Tank Farm samples. These results will then be used by the DWPF to calculate the chemical composition of the glass, which will be reported in the Production Records. The composition for each of the canistered waste forms produced by a macro-batch will be reported as average values for each component for the entire macro-batch. Standard deviations will also be appropriately calculated and reported for each component for each macro-batch, based on the entire set of analyses performed on process batches.

The errors associated with this strategy will be characterized during the DWPF Startup Test Program, when feed and glass samples will be routinely taken and analyzed in the DWPF. The precision and accuracy of the determination of the glass composition will be calculated based on the results of the DWPF Startup Test Program, and will be reported in the Waste Form Qualification Report. Preliminary estimates based on SRNL experience with similar equipment are also provided in the WQR.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

During each sludge batch at least one glass sample will be taken from the glass pour stream as it enters the canister and archived at the SRNL Shielded Cells Facility per standard procedure. Analysis of the sample will be performed at the request of DWPF.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.200.2. They are:

- Development of equipment and methods to sample the slurry feed material in the DWPF process vessels.[1]
- Development of methods for analyses of the major components in each process batch.[2-6] This includes demonstration of these methods in the laboratory with non-radioactive simulants, and in remote facilities with actual radioactive waste.
- Conversion of the analytical methods into procedures for use in the DWPF itself.
- Development of a relationship between feed composition and glass composition.
- Estimation of the error in the reported composition. This activity will be performed as part of the Startup Test Program, and will be based on analyses of the components of the error, and on comparisons of the reported composition (based on analyses of feed material) to the actual composition of the glass.
- Development of analytical methods for samples of production glass.

Sampling of Feed Material from Process Vessels

In the DWPF, feed material will be pumped out of each process vessel, through a recirculating sample loop, and back into the process vessel. This recirculating loop carries feed material from the process vessel in the canyon cell to the DWPF laboratory. The recirculating loop limits the amount of radioactive material in the laboratory, while still providing a sample which is representative of the contents of the process vessel.

To take a sample, a portion of the feed from the recirculating loop is diverted into a sampling container in the laboratory. The sampling container is then removed, and the contents prepared for analysis.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

Analysis of Feed Material

Samples of melter feed slurry can be prepared for analysis using one of two methods. The samples will either be converted to glass and then analyzed or the slurry will be directly analyzed without vitrification. After vitrification of the melter feed slurry, the vitrified sample is dissolved for analyses. For samples analyzed without vitrification (i.e., direct analysis method), the slurries are dissolved and then analyzed. For these analyses a vitrification factor for conversion to a glass basis will be utilized. The primary analysis technique to be used is Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES).

Waste Form Qualification Report (WQR) Volume 2 will contain descriptions of each of the analytical methods. Demonstrations of their application on non-radioactive simulants, and in remote facilities on actual radioactive waste slurries and glasses, by SRNL, will also be reported. Simulant and radioactive testing of the direct analysis method will also be reported. Additionally, a level of confidence will be established that the two analytical methods provide comparable results under production conditions (i.e., side-by-side testing). The DWPF will continually evaluate (and modify, as necessary) each of the methods used in the DWPF laboratory.

Because of the importance of glass composition, the DWPF laboratory has instituted a rigorous quality assurance and control program for slurry sampling and analyses. This is described in more detail in the glass product control program description (see Part 3, Item 500). The objectives of the program are to ensure the accuracy of the analytical values reported, and to control the precision so that it is within expected values.

Glass standards will be frequently analyzed. Calibration standards for analytical methods will be materials which are traceable to the National Institute of Science and Technology (NIST) or to other nationally recognized sources.

Feed to Glass Correlation

The DWPF will report the chemical composition of the glass based on analyses of melter feed samples from the SME. Because the feed samples are vitrified prior to analysis or converted to a vitrified basis using a vitrification factor, analyses of feed samples are actually analyses of equivalent glass samples. Thus, the DWPF assumes that analysis of feed samples is equivalent to analysis of glass leaving the melter.

During production, the composition of canistered waste forms produced during processing of a macro-batch will be reported as the average of the analyses of vitrified feed samples from all the process batches produced from that macro-batch. This introduces an error by neglecting the heels from previous batches left in process vessels. The magnitude of this error will be determined during the Startup Test Program.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

During the Startup Test Program, the DWPF will attempt to reliably predict the composition of the glass in individual canisters from feed analyses. The SME, MFT, and melter are each expected to act as well-stirred vessels for normal operating conditions. However, when large changes in feed composition occur (e.g., changing from Purex to HM feed), material flow through the melter may change to plug flow.

Estimates of Error of Reported Composition

During production, the DWPF will report the chemical composition of the glass from a macro-batch based on analyses of melter feed samples from the SME batches produced from that macro-batch. This introduces an error by neglecting the heels from previous batches left in process vessels. This source of error along with other sources of error will be characterized during the Startup Test Program and reported in Volume 2 of the WQR.

The reported composition will be subject to the following sources of error:

- Feed non-uniformity
- Sampling variability
- Variability due to the analytical system
- Error in calculation of macro-batch composition
- Process variability

Glass Sampling

At least one glass pour stream sample will be taken by DWPF during the processing of each sludge batch, analyzed as necessary and archived at the SRNL Shielded Cells Facility. These samples may be characterized at the request of DWPF should additional testing requirements be identified in the future but are no longer required for batch sampling confirmation.

Startup Test Program

During the Startup Test Program (see Appendix 1.200.3), statistically designed tests will be performed to estimate the error in the reported composition. A major goal of the tests will be to determine quantitatively how well the macro-batch average for each element (determined from feed samples) represents the contents of actual canisters of glass. The reported glass composition, based on analyses of feed material, will also be compared to analyses of samples of glass taken from canisters. Long-term and short-term variability will be characterized in a statistically defensible manner and the results reported in Volume 2 of the WQR.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

Documentation

The Waste Form Qualification Report Volume 2 will describe the slurry sampling system and the analytical methods for determining the glass composition during production. Reports of the results of experimental tests of the methods will also be included. Estimates of the errors due to process batch non-uniformity, sampling, analyses, and process variability will be provided from pilot plant testing, testing with simulated feeds in the laboratory and remote testing using radioactive materials. Determinations of the precision and accuracy of the DWPF laboratory procedures will also be reported.

The Production Record for each canistered waste form will include the elemental composition of the glass. The values reported will be based on the numerical averages of the individual elemental analyses for all of the process batches corresponding to the macro-batch, expressed as oxides in the glass. The number of samples averaged, and the standard deviations, appropriately calculated, of the analytical values for each element, will also be reported. The reported chemical composition will be the same for all canistered waste forms produced from a given macro-batch of feed.

References

1. D. E. Snyder and D. L. Gunnels, "Remote Operation of Defense Waste Processing Facility Sampling Stations," **Proceedings, 33rd Conference on Remote Systems Technology**, American Nuclear Society, 90-93 (1985).

2. C. J. Coleman, R. A. Dewberry, A. J. Lethco, C. D. Dennard, "Analytical Methods and Laboratory Facility for the Defense Waste Processing Facility," **Proceedings - 28th Oak Ridge National Laboratory Conference on Analytical Chemistry**, W. R. Laing (ed.), Lewis Publishers, Chelsea, MI, 337-43 (1986).

3. C. J. Coleman, "Analyses of Nuclear Fuel and High-Level Waste by Inductively Coupled Plasma-emission Spectroscopy," **Analytical Spectroscopy**, W. S. Lyon (ed.), Elsevier, New York, 195-99 (1986).

4. C. J. Coleman, E. W. Bauman, N. E. Bibler, R. A. Dewberry and E. F. Sturcken, **Analysis of Radioactive Waste and Glass for a Defense Waste Solidification Plant**, USDOE Report DP-MS-87-23, E. I. DuPont de Nemours & Co., Savannah River Laboratory, Aiken, SC 29808 (1987).

5. C. J. Coleman, N. E. Bibler, R. A. Dewberry, "Analysis of High Level Radioactive Glasses and Sludges for the Savannah River Site," **Waste Management 90, 2**, Roy G. Post (ed.), 651-7 (1990).

6. R.S. Beck, et al., **Results of Scoping Work for Insert Use at DWPF**, USDOE Report WSRC-TR-97-0076, Westinghouse Savannah River Company, Aiken, SC 29808 (1997).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

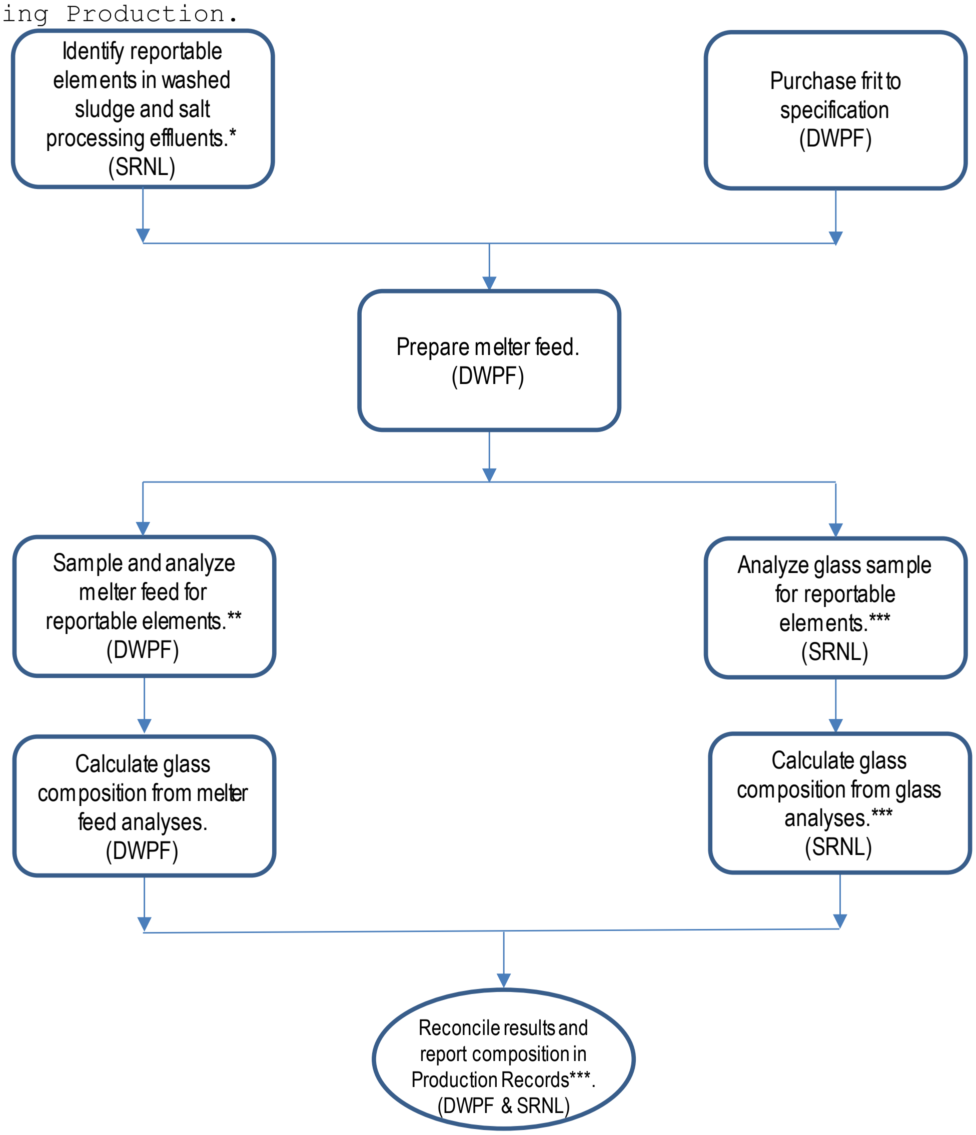
TABLE 3.200.1 Major Elements (> 0.5 wt % of the glass) and Source of those Elements

Component	Source
Al	Sludge
B	Frit
Ca	Sludge
Fe	Sludge
Li	Frit
Mg	Frit, sludge
Mn	Sludge
Na	Frit, MST, sludge
Ni	Sludge
Si	Frit, sludge
Ti	MST
U	Sludge

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

FIGURE 3.200.1 Strategy to Determine Chemical Composition of DWPF Glass during Production.

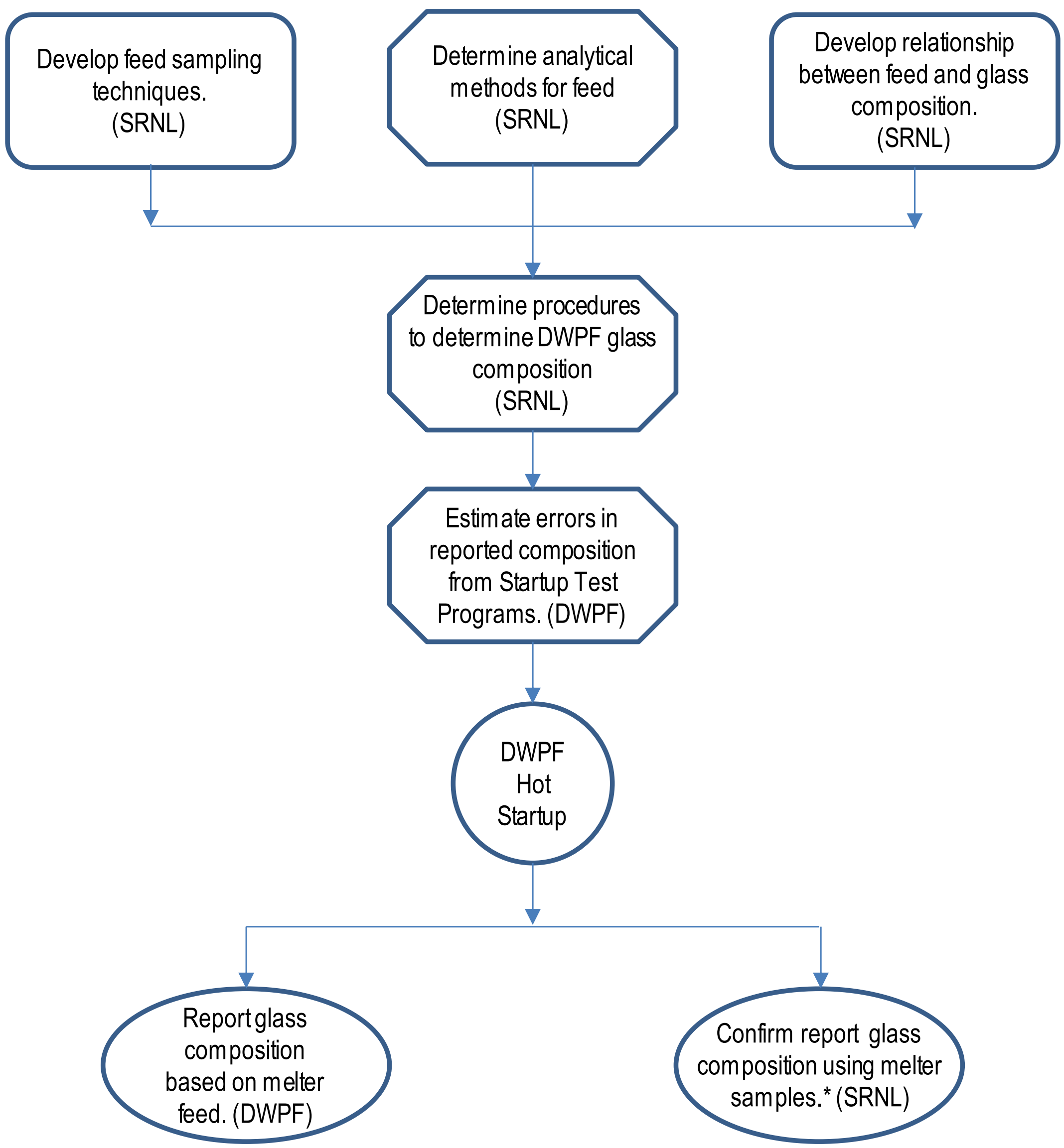


*All elements present in the sludge and salt effluent at >1wt% are reported
**All elements present in the melter feed/glass sample at >0.5wt% are reported.
***Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

FIGURE 3.200.2 Tasks planned to satisfy Specification 1.1.2, Chemical Composition during Production.



*Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

1.2 RADIONUCLIDE INVENTORY SPECIFICATION

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 percent of the total radioactive inventory for each waste type, indexed to the years 2015 and 3115.

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, and 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 WDP. 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.

Compliance Strategy

The DWPF Design-Basis waste glass will be used to identify the set of radionuclides to be reported. Each sludge batch from the Tank Farm will constitute a waste type for compliance with this specification. Estimates of both the total concentrations of individual radionuclides and the average concentration per canister will be developed for each of the waste types which will actually be vitrified in the DWPF. Estimates of the total quantities of individual radionuclides in DWPF glass will be based on the sum of the inventories of individual radionuclides currently stored in the waste tanks, and on anticipated future waste generation at SRS. For the latter, the radionuclide inventory of the Design-Basis glass will be assumed. For each radionuclide, the highest value of the concentration per canister for any waste type will be reported as the upper limit for any canistered waste form. Each estimated value will be indexed to both 2015 and 3115.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.300.1. These tasks are:

- Development of the radionuclide inventory for the Design-Basis glass. The Design-Basis glass represents an upper bound in terms of the dose rate, and heat generation rate, expected from DWPF canistered waste forms.

- Use of the radionuclide inventory of the Design-Basis glass to identify the set of radionuclides whose inventory must be reported.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

- Identification of the amounts of individual radionuclides in waste currently stored in the Tank Farm. As of December 31, 1991, it was estimated that the high-level waste (HLW) tanks at SRS contained 34,784,000 gallons of waste.[1] The estimated curie content of the current waste inventory is listed in Table 3.300.1.

- Identification of the waste types for waste currently stored at SRS. As discussed in Part 3, Item 100, these waste types correspond to the sludge batches in the Tank Farm, and their associated batches of salt.

- Estimation of the number of canisters produced in the future by SRS. This estimate will include future waste generation from nuclear materials production at SRS, as well as aqueous wastes from DWPF operations.

- Estimation of the total amount of radionuclides for each waste type. For future waste, the Design-Basis composition will be used. The total quantity to be shipped to the repository will be assumed to be the sum of the totals for each waste type.

- Determination of an upper bound for the concentration of each radionuclide in DWPF canistered waste forms.

Design-Basis Radionuclide Inventory

Using the radionuclide inventory of the Design-Basis waste (Part 1, Item 300), and the integrated flowsheet model for the DWPF (Part 3, Item 100), the radionuclide inventory of the Design-Basis glass has been developed. This inventory has been used as the basis for biological shielding, process cooling, and environmental release requirements for the DWPF. Several assumptions were made in developing the design basis radionuclide inventory.

- A standard blend of waste streams containing various radionuclides was developed, and assumed to be the constant input to the DWPF.

- Insoluble waste (sludge) is aged five years to decay short-lived isotopes.

- Soluble waste (feed for precipitation process) is aged 15 years, primarily to assure low concentrations of Ru-106.

The Design-Basis glass does not necessarily represent an upper bound for the concentration of any specific radionuclide. However, it is expected that it will provide an upper bound for many of the radionuclides because actual waste types in the SRS Tank Farm have been aged for longer periods (10 - 35 years) than the Design-Basis glass. Thus, concentrations of radionuclides with intermediate half-lives (Cs-137, Sr-90) in the Design-Basis glass should be higher. In addition, since the Design-Basis glass is the basis for design of the shielding for the DWPF, higher total concentrations of radionuclides emitting penetrating radiation are precluded by administrative controls.

Unfortunately, there is very little data about the concentrations of many of the radionuclides in Table 3.300.2 in actual waste. However, any other assumption about the upper bound would require speculation about the nature of future waste types, or divulgence of classified information. If the projections of the radionuclide inventories indicate that the concentrations of specific radionuclides in some specific waste type exceed those in the Design-Basis glass, then the maximum concentrations for that waste type will be reported in Volume 3 of the Waste Form Qualification Report (WQR) as the upper limit.

Radionuclides to be Reported

The radionuclide inventory of the Design-Basis glass includes projections of the amounts of individual radionuclides as a function of time after production of the glass. Table 3.300.2 lists all of the radionuclides, with a half-life greater than ten years, which comprise at least 0.01% of the radionuclide inventory (in curies) of the Design-Basis glass at any time up to 1100 years after production. This is the set of radionuclides which will be reported under this specification. The selection of the 0.01% limit is discussed in more detail in Part 3, Item 400. Use of this more inclusive limit ensures that all required radionuclides are reported for compliance with this specification.

It is not possible to predict when DWPF canistered waste forms will be shipped to a repository. The DWPF has elected to use the year 2015 as an assumed time of shipment. Thus, the projections indexed to the year 2015 will be considered to be those at time of shipment.

Radionuclide Inventory of Current Waste

The waste types designated Batches 1 - 4 in Part 3, Item 100, will be assumed to be the waste types comprising current waste, for purposes of compliance with this specification. For each waste type, the total radionuclide inventory for that waste type will depend on the amounts of individual radionuclides per unit mass of each waste type, and the total amount of each waste type in the SRS Tank Farm.

The information sources which will be used to identify the amounts of individual radionuclides for each waste type will include the results generated by computer codes based on radionuclide production, analytical data from waste samples, and results from the DWPF flowsheet calculations (see Part 3, Item 100). Available data from all of the radionuclide inventory sources will be compared to assure that the most reasonable values are used for each individual radionuclide. If a good technical basis for choosing one value over another cannot be established, the most conservative value will be chosen. As discussed in Part 3, Item 100, waste blending schemes developed by SRS Tank Farm personnel will be used to develop radionuclide inventory estimates for current waste.

The total amount of each radionuclide in each waste type will be estimated based on the volume of the sludge, and a factor to convert from waste volume to mass. The mass of each waste type will then be used to determine the total number of canisters to be produced from each waste type.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

When samples are taken of waste and glass from the initial feed to the DWPF (Batch 1), the concentration of the radionuclides listed in Table 3.300.2 for the waste and glass samples will be compared to the projections. These will provide confirmation of the projected radionuclide inventories.

Future Waste

The radionuclide inventory of the Design-Basis glass will also be used to project the radionuclide content of waste to be generated in the future. SRS production forecasts will be used to project the amount of waste to be generated in the future (and thus the number of canistered waste forms to be produced in the DWPF). Since the composition of waste to be generated in the future is not known, the Design-Basis radionuclide inventory will be assumed for future waste.

Total Amount of Individual Radionuclides in DWPF Glass

The total amount of individual radionuclides in projected DWPF glasses will be calculated by adding the amount of each radionuclide in all of the canisters of each waste type for current waste to the amount of that radionuclide assumed to be produced in the future.

Determination of Upper Limit for each Radionuclide

The specification requires that the DWPF determine an upper limit for each radionuclide in any canistered waste form. For each radionuclide, the average radionuclide inventory per canistered waste form for each waste type will be compared to determine a maximum concentration. This will then be reported as the upper limit in WQR Volume 3.

Qualification of Future Waste Glass Compositions

Because the radionuclide inventory of the Design-Basis glass was the basis for design of biological shielding for the DWPF, and for designs of the cooling systems for the Glass Waste Storage Buildings, it represents an upper bound expected for all DWPF canistered waste forms. If future wastes would produce glasses which exceed these properties, or would exceed the upper limit of any of the radionuclides, the DWPF proposes to apply Part 6, Item 200, in the following manner.

- A determination will be made of whether the new waste composition will produce a glass with different properties (radionuclide inventory, dose rate, or heat generation rate) than represented by the set of projected compositions. The repository program will be notified in writing of the results of that determination. If the properties of the new glass are bounded by the set of projected compositions (from above), the DWPF will propose to update the WQR to include the new composition, but will propose that no further action be taken. If the waste will produce a glass with properties outside the range of those already projected, then the DWPF will propose activities to ensure that the waste produces a glass which complies with specifications.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

- Once agreement is reached with the repository program on appropriate actions, they will be carried out and the WQR revised to reflect their results.

Documentation

Volume 3 of the Waste Form Qualification Report (WQR) will provide estimates of the total quantities of radionuclides expected to be made into borosilicate waste glass at DWPF, as well as estimates of the quantities of individual radionuclides expected to be present in the canistered waste forms to be produced from each waste type. For each radionuclide, an upper limit will also be provided in WQR Volume 3. These projections will be indexed to both 2015 and 3115. A comparison of the projected values to values measured for the initial feed to the DWPF (Batch 1) will also be reported.

References

1. Oak Ridge National Laboratory, **Integrated Data Base for 1991: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics**, USDOE Report RW-0006, Revision 7, U. S. Department of Energy, Washington, DC (1991).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

TABLE 3.300.1 SRS High-Level Waste Fission Product Inventory as of December 31, 1991.*

Total Volume of waste, m^3 (gals):	132,000 (34,800,000)
Total Activity, 10^6 Ci:	562
Total fission product activity in Tank Farm (Major species are Sr-90/Y-90, and Cs-137/Ba-137m, each 46% of curie content)	559
Total actinide activity in Tank Farm (Major species are Pu-238, 53% of curies; and Pu-241, 46% of curies)	3
Total heat output, kW:	1566
Total heat from fission products	1512
Total heat from actinides	54

*Values based on estimates from SRS Tank Farm personnel.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

TABLE 3.300.2 Radionuclides to be included in projected radionuclide inventories.*

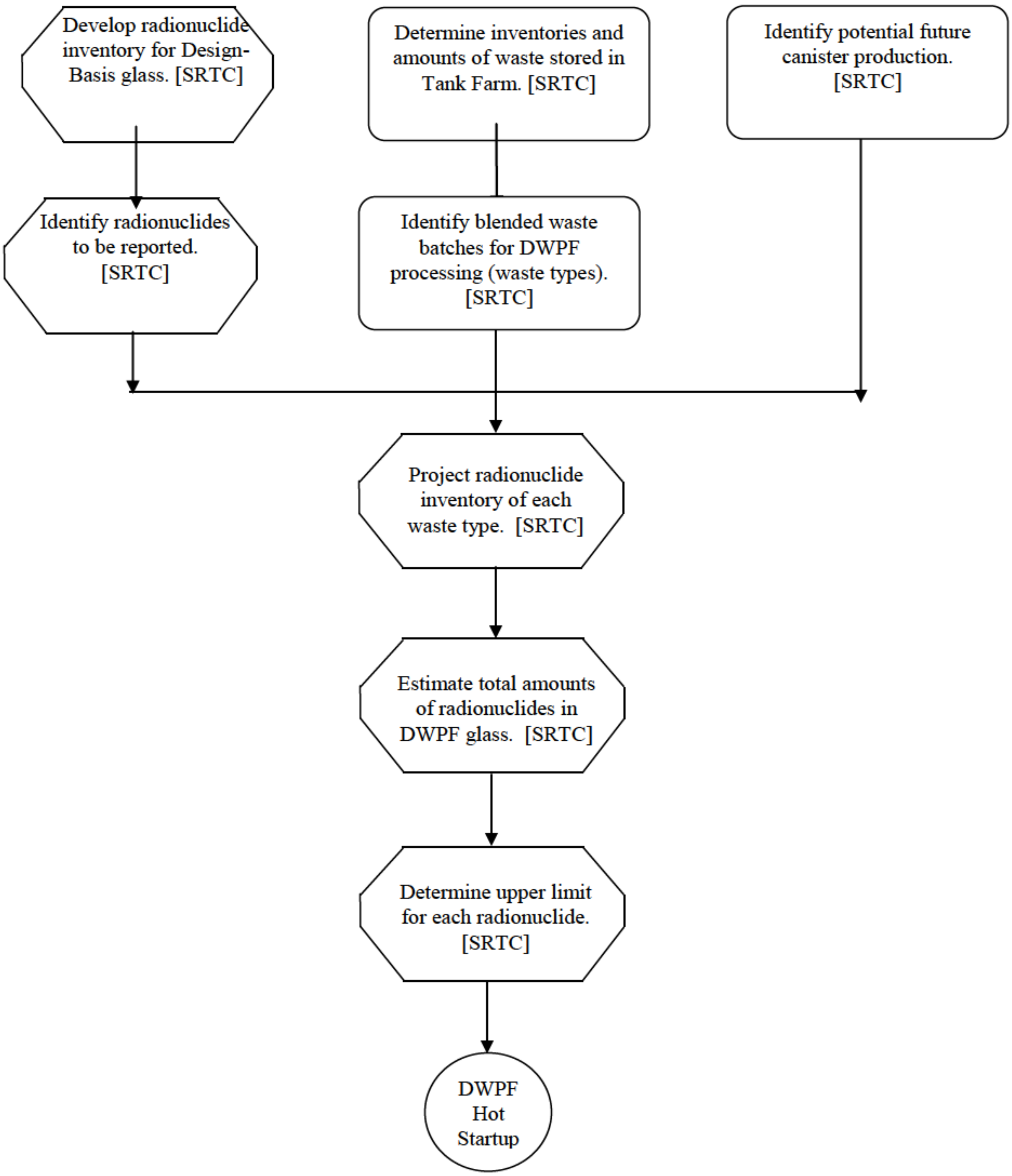
RADIONUCLIDE	REASON FOR REPORTING
Ni-59	> 0.01%, for all t > 400 years
Ni-63	> 0.01%, for 200 years < t < 900 years
Se-79	> 0.01%, for all t > 200 years
Sr-90	> 0.01%, for all t < 500 years
Zr-93/Nb-93m	> 0.01%, for all t > 200 years
Tc-99	> 0.01%, for all t > 80 years
Pd-107	> 0.01%, for all t > 500 years
Sn-126	> 0.01%, for all t > 200 years
Cs-135	> 0.01%, for all t > 300 years
Cs-137	> 0.01%, for all t < 700 years
Sm-151	> 0.01%, for all t
Th-230	> 0.01%, for all t > 1000 years
U-234	> 0.01%, for all t > 200 years
U-238	> 0.01%, for all t > 500 years
Np-237	> 0.01%, for all t > 500 years
Pu-238	> 0.01%, for all t
Pu-239	> 0.01%, for all t > 45 years
Pu-240	> 0.01%, for all t > 45 years
Pu-241	> 0.01%, for all t < 200 years
Pu-242	> 0.01%, for all t > 500 years
Am-241	> 0.01%, for all t > 45 years
Am-243	> 0.01%, for all t > 800 years
Cm-244	> 0.01%, for all t < 100 years

* $\tau_{1/2}$ > 10 years, concentration > 0.01% of the total curie inventory of the design-basis glass at any time up to 1100 years.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

FIGURE 3.300.1 Tasks planned to satisfy Specification 1.2.1, Radionuclide Inventory Projections.



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

1.2.2 Radionuclide Inventory During Production

The Producer shall provide in the Production Records estimates of the inventories of individual reportable radionuclides for each canister and for each waste type. The Producer shall also report the estimated error of these estimates in the WQR.

Compliance Strategy

The strategy for determining the radionuclide inventory of DWPF glass (shown in Figure 3.400.1) is similar to that for the chemical composition during production (Part 3, Item 200). It is based on the relatively constant nature of the sludge feed to the DWPF over the life of each Tank Farm sludge batch, and of the salt effluent feed over the life of each Tank Farm salt effluent batch. Thus, for purposes of compliance, a macro-batch constitutes a waste type.

The DWPF will report the contents of all radionuclides having a half-life > 10 years and making up at least 0.01% (on a curie basis) of the radionuclide inventory of the Design-Basis glass at some time between the time of production of the glass and 1100 years after production. The DWPF has chosen to report this fixed set of species because of the difficulty of determining which radionuclides will constitute 0.05% at some time up to 1100 years after production, for a specific macro-batch. By choosing a more stringent limit (0.01%), the DWPF ensures that all radionuclides which might be included are reported. NOTE: For macrobatches analyzed after 2015, the initial index year will be the year of radionuclide analysis (e.g., 2017) and the final index year will continue as 3115(see Volume 4 of the Waste Form Qualification Report). Decay calculations will be made for 2115, 2215, 2315 and every 100 years up to the final index year of 3115.

Samples of the waste in the Tank Farm will be taken from each sludge and salt batch which constitute the macro-batch. The concentrations of the specified radionuclides in the individual waste streams will then be determined. These analyses will be used to develop correlations between these radionuclides and species which can be measured directly in the DWPF laboratory using process batch samples from the SME. Analyses of samples of waste from the Tank Farms will also be used to establish estimates of the errors of the calculational methods, which will be reported in the Waste Form Qualification Report.

The average concentration of each measured radionuclide in each canister for the macro-batch will be reported in the Production Records, as well as the total inventory of each radionuclide in the macro-batch. If a radionuclide cannot be detected in either the feed to the melter, or in samples from the Tank Farm, then its content will be reported as "Below Detection Limits."

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

The analytical methods will be demonstrated in SRNL's Shielded Cells Facility before radioactive operations begin in the DWPF. Initial estimates of the errors of the methods, and their detection limits, will be made based on these demonstrations, and reported in Volume 4 of the Waste Form Qualification Report. Glass sample(s) taken from the molten glass stream will be archived and may be characterized as requested by DWPF for future additional data purposes.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.400.2. These are:

- Development of methods to calculate the concentration of those radionuclides which cannot be measured directly in the DWPF.

- Development of correlation between glass and feed.

- Estimation of the errors in the reported radionuclide inventory.

Analysis of Feed Material in the DWPF

In Volume 4 of the Waste Form Qualification Report, the analytical methods of radionuclide inventory determination will be described. Fundamentally, DWPF will indirectly measure radionuclides by establishing a correlation between the composition of feed from the Tank Farms and the composition of melter feed slurry. Demonstrations of their application to synthetic radioactive samples and actual radioactive waste samples will also be reported. The latter studies will establish the minimum error which can be expected from application of these methods to DWPF feed materials, in practice.

Estimates of Error of Reported Radionuclide Inventory

During production, the radionuclide inventory of canistered waste forms produced during processing of a macro-batch will be reported as the average of the analyses of all the process batches produced from that macro-batch. This introduces an error by neglecting the heels from previous batches left in process vessels. The magnitude of this error will be determined during radioactive operations and reported in Volume 4 of the Waste Form Qualification Report.

The reported radionuclide inventory will be subject to each of the sources of error identified in Part 3, Item 200, for determination of the chemical composition of the glass. Each of these sources of error (listed below) will be characterized during the Startup Test Program or during initial DWPF operation.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

- Feed and sampling variability
- Variability due to the analytical system
- Errors in calculation of macro-batch radionuclide inventory
- Errors in correlation functions
- Process variability – The amount of glass in each canister is an additional source of error that is not applicable to the reported chemical composition.

Glass Sampling

At least one glass pour stream sample will be taken by DWPF during the processing of each sludge batch, analyzed as necessary and archived at the SRNL Shielded Cells Facility. These samples may be characterized at the request of DWPF should additional testing requirements be identified in the future but are no longer required for batch sampling confirmation.

Documentation

Volume 4 of the Waste Form Qualification Report will include a report on the methods to be used to determine the radionuclide inventory during production. The precision and accuracy of the methods used, based upon demonstrations in SRNL's Shielded Cell Facility, and analyses of samples from the Tank Farm, will also be reported. The Waste Form Qualification Report will also contain estimates of the errors of calculational algorithms used.

The Production Record for each canistered waste form will include estimates of the content of each reportable radionuclide. For all radionuclides, the reported inventory for each will be expressed as the average curies per canister for the macro-batch, and will be reported as a single value for each canister in the entire macro-batch. A total inventory for the entire macro-batch will also be reported.

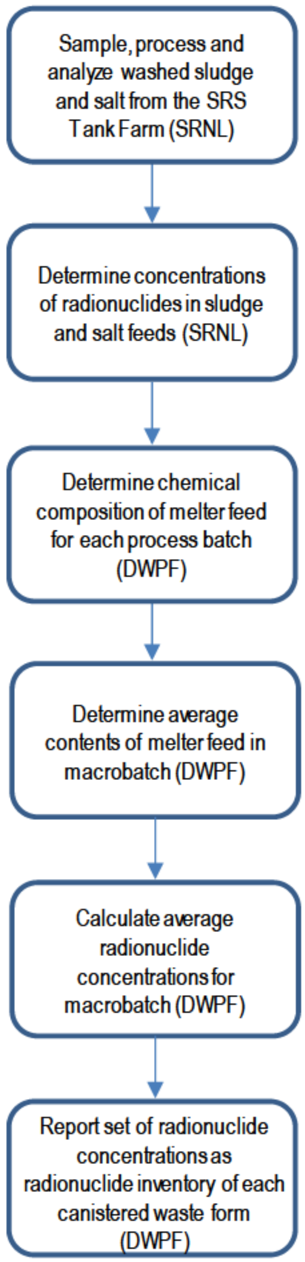
References

1. J. W. Ray, "Defense Waste Processing Facility (DWPF) Path Forward on DOE-EM Waste Acceptance Product Specifications (WAPS) 2015 Index Year for Radionuclide Reporting," SRR-WSE-2018-00020, Revision 0, Savannah River Site, Aiken, SC (2018).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

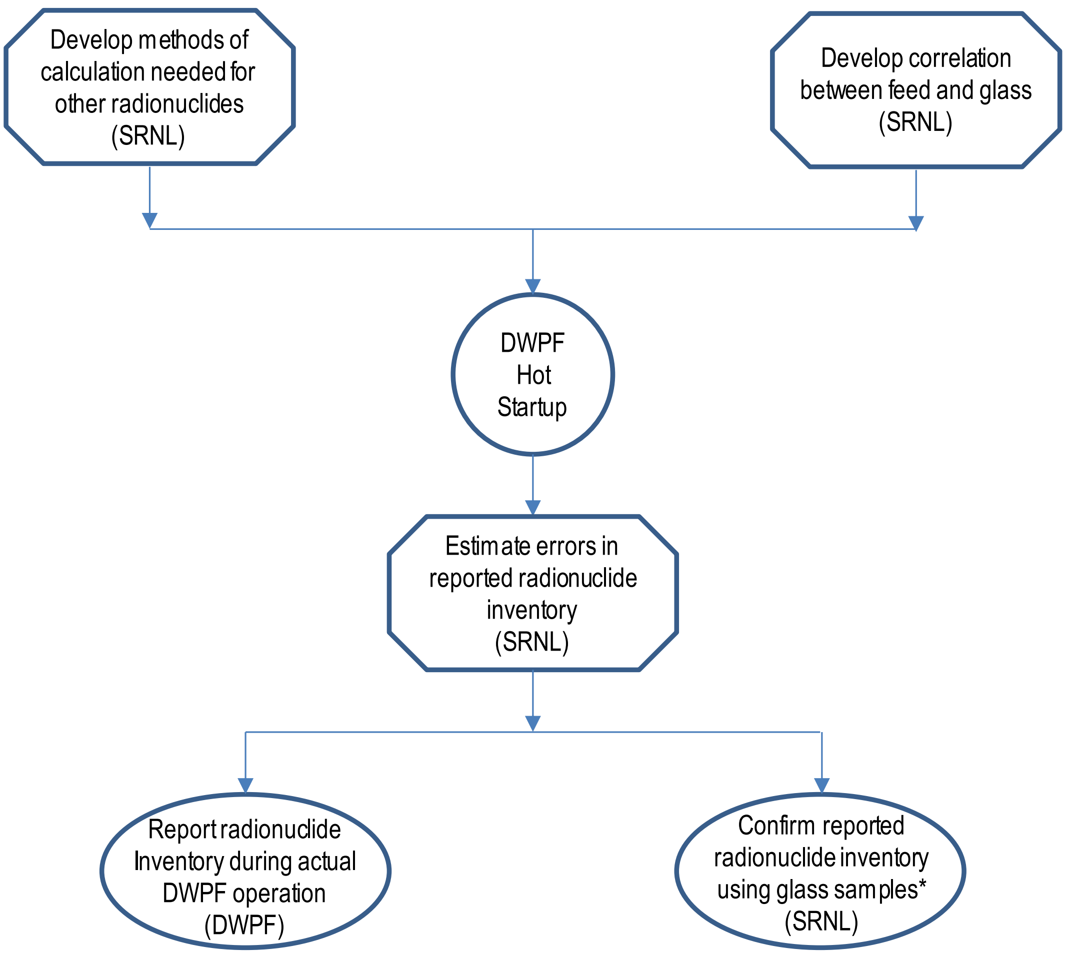
FIGURE 3.400.1 Strategy to Determine Radionuclide Inventory of DWPF Glass during Production.



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

FIGURE 3.400.2 Tasks planned to satisfy Specification 1.2.2, Radionuclide Inventory During Production.



*Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

The Producer shall demonstrate control of waste form production by comparing, either directly or indirectly, production samples to the Environmental Assessment (EA) benchmark glass[^]. The Producer shall describe the method for demonstrating compliance in the WCP and shall provide verification in the Production Records. The Producer shall demonstrate the ability to comply with the specification in the WQR.

1.3.1 Acceptance Criterion

The consistency of the waste form shall be demonstrated using the Product Consistency Test (PCT)[**]. For acceptance, the mean concentrations of lithium, sodium and boron in the leachate, after normalizing for the concentrations in the glass, shall each be less than those of the benchmark glass described in the Environmental Assessment for selection of the DWPF waste form[***]. The measured or projected mean PCT results for lithium, sodium and boron shall be provided in the Production Records. The Producer shall define the statistical significance of the reported data in the WQR. One acceptable method of demonstrating that the acceptance criterion is met would be to ensure that the mean PCT results for each waste type are at least two standard deviations below the mean PCT results of the EA glass.

1.3.2 Method of Compliance

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

Production Records shall contain data derived from production samples, or process control information used for verification, separately or in combination. When using process control information to project PCT results, the Producer shall demonstrate in the WQR that the method used will provide information equivalent to the testing of samples of actual production glass.

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^ C.M. Jantzen, **Characterization of the Defense Waste Processing Facility (DWPF) Environmental Assessment Glass Standard Reference Material**, WSRC-TR-92-346, Westinghouse Savannah River Company, Aiken, SC (September 1992).

** C. M. Jantzen, **Nuclear Waste Product Consistency Test Method, Version 5.0**, WSRC-TR-90-539, Westinghouse Savannah River Company (January 1992). (Method A is used for radioactive production glass samples.)

*** U. S. Department of Energy, **Environmental Assessment — Waste Form Selection for SRP High-Level Waste**, USDOE Report DOE/EA 0179, Washington, D.C. (1982).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

Compliance Strategy

The product consistency specification requires comparison of the PCT results of production glass to those of the benchmark glass in the DWPF Environmental Assessment (EA). The DWPF will develop and characterize an EA Glass Reference Standard Material for this purpose. This glass will be based on the composition in Table 3-1 of the DWPF EA. The DWPF will procure the material, characterize its composition and variability, and determine mean values for Na, Li, and B releases on the PCT. These mean values will then become the reference for determining whether production glasses meet the specification.

The DWPF must control the glass composition to comply with the product consistency specification. The only parameters which the DWPF can directly control which affect the PCT results are the glass composition and the uniformity of the feed to the melter. The relative magnitude of the effects observed implies that the GPCP must concentrate on controlling the composition of the glass in order to satisfy the product consistency specification. The DWPF will develop a correlation between glass composition and PCT results for use in control of the vitrification process. For each of the projected waste types, the DWPF will demonstrate that an acceptable glass can be produced from that waste type before processing begins,and will demonstrate that the composition/PCT correlation can be applied.

The DWPF will also develop a Glass Product Control Program (GPCP) for control and verification of the consistency of the glass product during production. The GPCP will cover all facets of glass production, including qualification of waste for DWPF processing, process batch monitoring, process batch remediation (if necessary), glass pouring, and verification of product consistency in the Production Records. The chemical composition of the glass will be controlled by ensuring that each process batch of feed in the last feed preparation vessel, the Slurry Mix Evaporator (SME), will make acceptable glass. The glass composition/PCT correlation will be used to determine process batch acceptability. The correlation will be embedded in the Product Composition Control System (PCCS), which will take into account the uniformity of material in process vessels, errors in the sampling and measurement systems, and errors in the composition/PCT correlation itself. SME batches will be transferred forward for delivery to the melter only after there is confidence that they will produce acceptable glass.

Each macrobatch will constitute a "waste type" for purposes of compliance with the reporting requirements of this specification. The DWPF will provide verification of the consistency of the glass products for each macrobatch in the Production Records. This will include: the average PCT results predicted by the PCCS, and PCT results calculated using the average composition of the macrobatch (see Part 3, Item 200).

Studies demonstrating control of the results of the PCT through control of composition will be performed. These studies will range in scale from laboratory tests with actual waste in the SRNL Shielded Cells Facility, to engineering-scale (1/9-scale) testing with simulated waste, and, most importantly, to full-scale testing in the DWPF with the actual process equipment during the Startup Test Program.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.500.1. They are

- Identification of the variables to be controlled. As will be discussed below, the DWPF must concentrate on controlling the chemical composition of the glass to comply with the specification.

- Development and characterization of an EA glass Reference Standard Material.

- Development of a correlation between the chemical composition of the feed and the results of the PCT. This task includes determination of the error associated with the correlation.

- Demonstration that each of the projected compositions in Part 3, Item 100, is acceptable.

- Development of a Glass Product Control Program (GPCP), for control of glass product consistency during production. The GPCP includes the following elements:

    - Qualification of waste for DWPF processing.
    - Sampling and analyses of process batches in the SME.
    - Determination of the acceptability of process batches in the SME.
    - Adjustment of process batches in the SME, if necessary.
    - Confirmation that an acceptable glass has been produced.
    - Verification that a consistent glass product has been produced, in the Production Records.

- Characterization of the uniformity of material in process vessels (primarily the Slurry Mix Evaporator and the Melter Feed Tank), and the errors associated with the DWPF's sampling and analytical measurement systems. This task is discussed in Part 3, Item 200. The results of this task will be incorporated in the portions of the Product Composition Control System which are used by the Glass Product Control Program.

- Development of the Product Composition Control System (PCCS) for use as part of the Glass Product Control Program.

- Development of a glass sampler suitable for use in the DWPF, as part of the Glass Product Control Program.

• Demonstrations of the effectiveness of the Glass Product Control Program and its parts including

— Testing of the correlation between the chemical composition and the results of the PCT in both pilot-scale tests with simulated waste, and small-scale tests with actual waste.
— Testing of the control of composition in both pilot-scale tests with simulated waste, and small-scale tests with actual waste.
— Testing of the glass sampler during the Qualification Runs portion of the Startup Test Program.
— Demonstration of the use of the GPCP during the Qualification Runs portion of the Startup Test Program.

Identification of Important Variables

The properties affecting the performance of DWPF waste glasses on various leach tests have been extensively investigated over the last 15 years.[1-7] As part of this scrutiny, two in-depth studies of the mechanisms of reactions between waste glasses and aqueous solutions have been performed.[1,2]

Under the leadership of the Materials Characterization Center (MCC), the Leaching Mechanisms Program investigated the mechanisms by which repository groundwater and DWPF glass interact. This study, which involved university, industrial and DOE laboratories, concluded that the reaction mechanisms depend on the composition of the glass, the repository's environmental conditions (groundwater composition, pH and Eh, temperature, flow rate of water and amount of water), and the time of contact between glass and leachant.[1]

As part of its program to gain acceptance of DWPF glass, Savannah River National Laboratory has also carried out extensive investigations[2-7] of the mechanisms of reactions between glass and aqueous solutions. The first of these, which summarized the technical basis for the selection of borosilicate glass as the waste form for the DWPF, concluded that the performance of glass was governed by exactly the same factors identified in the MCC study.[2] Subsequent studies[3-7] have shown that the reactivity of glasses typical of those which will be produced in the DWPF are affected very little by variations in parameters such as melter residence time,[3] the size of the melter,[4] or crystalline content of the glass[2,5-7]. (It has also been shown that DWPF-type glasses do not adversely affect either the Eh or the pH of groundwaters representative of candidate repository environments.[8-12]) Thus, the reactivity of the DWPF product toward aqueous solutions can best be controlled by controlling the chemical composition of the glass.

This position can also be justified on a theoretical basis. The hydration thermodynamic approach,[13-15] originally developed to explain differences in durability of ancient glasses, leads to the prediction that the performance of glass should depend most strongly on the chemical composition of the glass, and very little on other process parameters.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

The DWPF has chosen to control glass composition through control of the composition of the feed in the last feed preparation vessel, the Slurry Mix Evaporator (SME).[16] Direct control of the glass composition is not possible because of the continuous nature of the DWPF process, and the virtual impossibility of collecting and recycling unacceptable glass. Consequently, the glass composition must be controlled through control of the feed composition. The SME has been selected as the control point because it is the last process vessel through which direct chemical additions are routinely made. Thus, it can be used to adjust feed batches which might otherwise make unacceptable product. Because no further chemical additions are routinely made downstream, the controls applied to material in the SME are highly unlikely to be overridden by actions downstream.

Implicit in the free energy of hydration approach is the assumption that a glass (a single-phase amorphous material) has been made. The glass must not contain second phases (either crystalline phases or as the result of amorphous phase separation). An important facet of the Glass Product Control Program is demonstration that this assumption is valid for each sludge batch. The DWPF will also ensure that the melter feed has reached sufficient temperatures to produce a glass product which meets the specification before the molten glass is poured into a canister. Based on the results in reference 3, the minimum temperature is 750°C.

As a result of carrying out the programs described in this Item, other phenomena may be identified as important to compliance with this specification. If this occurs, the phenomena and their potential impacts on compliance with this specification will be described in Volume 5 of the Waste Form Qualification Report. The controls imposed to avoid adverse impacts from these phenomena will be described in Volume 6 (the Glass Product Control Program).

<u>EA Glass Standard Reference Material</u>

The product consistency specification requires extensive use of the EA glass for comparison purposes. The DWPF will procure and characterize a large amount of an EA Glass Standard Reference Material for its use, and that of other waste producers.

The specified composition of the glass is given in Table 3.500.1. It is based on the composition of the glass called "Typical" in Table 3-1 of the DWPF EA. The "Other" constituents listed in Table 3-1 included components such as $NaNO_3$, zeolite, and coal which break down during vitrification. It also included components such as uranium which would hinder free distribution of the Standard Reference Material. The target composition was thus derived by converting the components which would break down during vitrification to glass oxides (e.g., $NaNO_3$ to Na_2O), excluding uranium (work at SRNL has previously shown that uranium does not affect the durability of SRS waste glasses), and then normalizing the resulting all-oxide composition to 100%.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

This material will be characterized as follows:

- The chemical composition (including the iron redox ratio) of this material will be determined and uncertainties established.

- An internal (to SRNL) "round robin" PCT will be performed using this material. The purpose of this activity is to provide values of the mean PCT results for use in qualifying PCT data measured prior to the availability of this material.

- All future testing involving the PCT will use this glass as an internal control, which will facilitate direct demonstrations of compliance with the product consistency specification.

Correlation Between Chemical Composition and PCT Results

Relationships will be developed between composite functions of the glass composition and the results of the PCT, in the following manner:

1) A set of glasses will be prepared which includes the range of expected DWPF compositions. These will contain a range of waste types, and waste loadings. This set of compositions will be selected to defensibly develop a correlation between the chemical composition of the glass and the PCT results.

2) DWPF analytical methods will be used to characterize each glass.

3) The PCT protocol will be strictly followed, and each of the species specified in the WAPS monitored.

4) The ability of three types of composite functions of composition to represent the PCT results will be determined. These include the free energy of hydration approach, a modified version of the free energy of hydration approach, and a strictly empirical relationship. The free energy approach will be tested because of its successful application to a wide variety of test conditions and glass compositions.[17] Currently, SRNL is performing experiments to demonstrate the use of the free energy of hydration, calculated from the chemical composition of the glass, as a method of pooling the effects of each of the chemical components into a single value representing the entire composition. This method appears to be satisfactory for DWPF use. However, it is known that addition of a kinetic parameter to the thermodynamic free energy approach (e.g., one reflecting the effects of composition on the ultimate pH of the leachant) can better represent experimental results.[14] In addition, a strictly empirical fit of glass composition to PCT data in principle should provide a relationship with the least error (at the cost of having unknown predictive value outside the range of compositions over which it was generated).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

5) One of the correlations tested above will be selected for deployment in the facility. This selection will take into consideration the following criteria:

Reliability. The DWPF has no method of reworking unacceptable glass. Thus, the correlation selected must have a high probability of detecting an unacceptable composition. Conversely, the correlation selected must also minimize false indications of poor quality to ensure that the process is not held up unnecessarily. The error of each correlation between composition and PCT results will be used as the measure of the reliability of the correlation.

Ease of application. The correlation selected must be applied in a production setting, by engineers who will not have an in-depth knowledge of glass science. Thus, the correlation must be simple to understand and to implement. In addition, it is desirable that the correlation selected agree with known principles of glass durability (e.g., the correlation should be consistent with such concepts as glasses higher in silica being more durable than glasses high in fluxes such as boron or alkali metals).

Waste variability. Waste generation through production of nuclear materials will continue at Savannah River for the foreseeable future. The correlation selected must be reliable not only for the varied wastes currently stored but for new kinds of wastes, as they are generated in future SRS processes.

Trace components. The correlation selected must take into account potential effects of trace components in a consistent manner, and weight their importance appropriately.

Glass performance. Though not required, it is desirable that the correlation be consistent with published results on the effects of glass composition on the reactions between glass and water.

Characterization of Projected Glass Compositions

In Part 3, Item 100, several projected glass compositions are provided. These include projected compositions for glasses which will be produced over the first ten years of production, the composition of the Design-Basis glass, and the composition of two hypothetical glass compositions. The Design-Basis glass composition and each of the projected glass compositions have been formulated to produce an acceptable glass product. The two hypothetical glass compositions were formulated as bounding cases for the DWPF product. The HM composition in Part 3, Item 100, is based on the SRS sludge highest in aluminum. The HM composition also assumes minimal addition of PHA (see Part 1, Item 300) to the facility, and thus is low in Na, K, and B. Thus, the HM composition should release the lowest amounts of Li, Na, and B to solution on the PCT (based on the free energy approach). Conversely, the Purex composition should release the most to solution on the PCT, since the sludge composition used has the lowest aluminum content, and the maximum possible addition of PHA has been assumed.

Before production begins, samples of each of these glasses will be subjected to the PCT, and compared to the EA glass. This will demonstrate that the projected glass compositions are capable of meeting the specification, and that even the worst case DWPF glass will be better than the EA glass.

Glass Product Control Program

The elements of the Glass Product Control Program for glass chemical composition include qualification of macrobatches for DWPF processing, specification of a SME sampling regimen (number of samples, number of analyses per sample), SME sampling and sample analyses, determination of feed acceptability, adjustment of feed composition (if necessary), reporting and glass sampling.

Qualification of macrobatches for DWPF processing. Before a macrobatch of waste is processed in the DWPF, samples of the sludge batch and salt effluent batch (i.e., samples of actual waste) will be analyzed for chemical composition and radionuclide content. The samples will then be processed through the Shielded Cells Facility. In addition, for each sludge batch, a variability study will be performed, which establishes the applicability of the correlation between the PCT results and the chemical composition for that sludge batch. If the relationship does not apply over the entire range of compositions, then the DWPF will either constrain the process to operate only within the region over which the relationship does apply, or will develop a new relationship for that sludge batch.

SME sampling and analyses. Samples of each process batch of feed in the SME will be taken and analyzed (see Part 3, Item 200). The number of samples initially will be determined during the Qualification Runs, based on the number of measurements necessary to satisfy the product consistency specification. The analytical techniques will be the same as those discussed in Part 3 / Item 200.

Determination of acceptability. For each process batch, the chemical composition of the samples of feed from the SME will be used to determine acceptability. If it is determined that the process batch would produce a glass product which would not satisfy the product consistency specification, the process batch will be held in the SME, and its composition adjusted and re-analyzed. If it determined that the process batch will produce glass which satisfies the specification, the process batch will be transferred to the Melter Feed Tank, and then to the melter.

Feed adjustment. If necessary, the feed will be adjusted with frit, additional sludge, or other trim chemicals. The process batch in the SME will be re-sampled and analyzed again after adjustment to confirm that it has been successfully remediated. Transfer of the process batch to the Melter Feed Tank will only be allowed when it has been determined that the process batch will produce glass which satisfies the specification.

Reporting. The DWPF has elected to report on a macrobatch basis, and thus has identified the macrobatch as the waste type in the specification. In the Production Records, the DWPF will verify that the glass product satisfies the product consistency specification through two forms of evidence. The set of predicted PCT results (calculated as part of the determination of SME batch acceptability) from all SME batches in the macrobatch will be used to calculate an average and standard deviation which will be included in the Production Records. The average chemical composition of the macrobatch will also be used to develop a separate prediction of the PCT results for inclusion in the Production Records. As requested by the Department of Energy's Office of Environmental Management (DOE-EM), the DWPF will also include the predicted PCT results for each SME batch in the Production Records.

Glass sampling. A glass sampler has been developed and tested to support archival of glass samples.

Product Composition Control System (PCCS)

The DWPF has developed a software system, the PCCS, for control of the chemical composition of process batches of feed throughout the process. The PCCS contains composition/property correlations for important processing characteristics (e.g., viscosity), as well as for glass durability. The PCCS also takes into account the uncertainties associated with the analytical system and the composition/PCT correlation itself. The composition/PCT correlation (described earlier in this Item) will also be embedded in the PCCS.

The PCCS will be an important tool in the GPCP to ensure that each process batch of feed produces glass which satisfies the specification by controlling its chemical composition. The PCCS will be tested during the Qualification Runs portion of the Startup Test Program. The predicted performance of the glass on the PCT (from the PCCS) will be compared to the PCT results of glass samples taken during pouring, and from samples of the glass taken from each canister. The Qualification Runs are discussed more fully in Appendix 1.200.3.

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ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

Glass Sampler

A glass sampler suitable for routine DWPF use has been developed and tested. Approximately 30 g of glass will be taken from the flowing stream of molten glass as it is poured from the melter into the canister. During the Qualification Runs (see Appendix 1.200.3), glass samples taken with the reference sampler from the pouring glass streams will be compared to samples taken from the canisters directly. Both the chemical composition and the performance of the glass on the PCT will be compared. This test is intended to establish that the glass sample is representative of the contents of the canister.

Demonstrations of Control of Composition

SRNL will demonstrate the effectiveness of the GPCP approach in both engineering-scale tests with simulated waste, and small-scale tests with actual waste. For both sets of tests, the composition/PCT correlation will be used to formulate glasses which should be acceptable, even including errors based on melter feed non-uniformity, sampling, analyses, and the composition/PCT correlation. Processing of the feed, including feed preparation, feed adjustment, and vitrification, will then be performed in a manner representative of the DWPF process. The glass product will then be characterized using the PCT. The predicted PCT results will then be compared to the actual performance of the glass to determine the effectiveness of the control actions in producing an acceptable product.

The ability of the GPCP to effectively control production of the glass product will be demonstrated during the Qualification Runs (see Appendix 1.200.3). The results of these runs will be reported in the Waste Form Qualification Report (WQR).

Documentation

Volume 5 of the Waste Form Qualification Report (WQR) will detail the development of the correlation between the chemical composition of the glass to the PCT results. The Product Composition Control System, or a functionally equivalent method, will be described in detail, as well as the testing of the PCCS which will be performed during the Qualification Runs. The results of the effort to demonstrate the acceptability of each of the projected glass compositions will also be included in this volume.

The accuracy and precision of the methods of control will also be reported in WQR Volume 5. This volume will also report on the use of the glass sampler, and the comparison of the samples taken from the pouring stream with samples taken from the canister itself. The methods of calculation which will be used in the Production Records will be presented. If any other phenomena are identified which could affect the ability of the DWPF glass to comply with this specification, they will also be described in Volume 5.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

The Glass Product Control Program will also be described in the WQR (Volume 6). This part of the WQR will

(1) Provide a description of the product and process.

(2) Identify the requirements for the product (primarily product consistency).

(3) Identify the process variables which affect the ability of the glass product to meet the requirements (chemical composition of the feed, and any other variables which have been identified).

(4) Describe those actions which will be taken to control the chemical composition, and glass pouring, and to verify through reporting in the Production Records that it has been controlled.

(5) Identify the organizations taking those actions.

(6) Describe the method of reporting those actions.

The Production Record for each canistered waste form will contain the chemical composition of the glass (see Part 3, Item 200), the average of the predicted PCT results (from the PCCS) for each process batch in the macrobatch, and a prediction of the PCT results calculated from the chemical composition. The standard deviation of the average of the PCCS predictions will also be calculated and reported. In addition, the PCT projections for the individual process batches will also be included in the Production Records. Each of these will be compared to the mean PCT results of the EA glass.

References

1. J. E. Mendel (ed.), **Final Report of the Defense High-Level Waste Leaching Mechanisms Program**, USDOE Report PNL-5157, Battelle-Pacific Northwest Laboratory, Richland, WA (1984).

2. M. J. Plodinec, G. G. Wicks, and N. E. Bibler, **An Assessment of Savannah River Borosilicate Glass in the Repository Environment**, USDOE Report DP-1629, Savannah River Laboratory, Aiken, SC (1982).

3. D. F. Bickford, P. Hrma, B. W. Bowan, III, "Control of Radioactive Waste Glass Melters: II, Residence Time and Melt Rate Limitations," **J. Am. Cer. Soc.**, **73**, 2903-15 (1990).

4. M. J. Plodinec, "Characterization of Savannah River Plant Waste Glass," **Waste Management 85**, 1, R. G. Post (ed.), 441-5 (1985).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

5. C. M. Jantzen, D. F. Bickford, D. G. Karraker and G. G. Wicks, "Time-temperature-transformation kinetics in SRTC glass," **Advances in Ceramics - Nuclear Waste Management**, 8, W. A. Ross and G. G. Wicks (eds.), 30-38 (1984).

6. D. F. Bickford and C. M. Jantzen, "Devitrification Behavior of SRTC Defense Waste Glass," **Scientific Basis for Nuclear Waste Management, VII**, G. L. McVay (ed.), Elsevier, NY, 557-66, (1984).

7. C. M. Jantzen and D. F. Bickford, "Leaching of Devitrified Glass Containing Simulated SRP Nuclear Waste," **Scientific Basis for Nuclear Waste Management, VIII**, C. M. Jantzen, et al. (ed), Materials Research Society, Pittsburgh, PA, 135-46 (1985).

8. N. E. Bibler and C. M. Jantzen, "Materials Interactions Relating to Long-Term Geologic Disposal of Nuclear Waste Glass," **Scientific Basis for Nuclear Waste Management**, X, J. K. Bates (ed), 47-66 (1987).

9. C. M. Jantzen and N. E. Bibler, "The Role of Groundwater Oxidation Potential and Radiolysis on Waste Glass Performance in Crystalline Repository Environments," **Scientific Basis for Nuclear Waste Management**, IX, L.O. Werme (ed.), Materials Research Society, Pittsburgh, PA 219-229 (1986).

10. N. E. Bibler, "Leaching Fully Radioactive SRP Nuclear Waste Glass in Tuff Ground-Water in Stainless Steel Vessels," **Advances in Ceramics - Nuclear Waste Management, 20**, D. E. Clark, et al.(ed), 619-626 (1986).

11. N. E. Bibler, G. G. Wicks and V. O. Oversby, "Leaching of SRP Nuclear Waste Glass in a Saturated Tuff Environment," **Scientific Basis for Nuclear Waste Management, VIII**, C. M. Jantzen, J. A. Stone and R. C. Ewing (eds.), 247-56 (1985).

12. G. G. Wicks, "Nuclear Waste Vitrification - The Geology Connection," **J. Non-Cryst. Solids, 84**, 241-50 (1986).

13. M. J. Plodinec, C. M. Jantzen, G. G. Wicks, "Thermodynamic approach to prediction of the stability of proposed radwaste glasses," **Advances in Ceramics - Nuclear Waste Management, 8**, W. A. Ross and G. G. Wicks (eds.), 491-95 (1984).

14. C. M. Jantzen and M. J. Plodinec, "Thermodynamic Model of Natural, Medieval and Nuclear Waste Glass Durability," **J. Non-Cryst. Solids, 67**, 207-23 (1984).

15. M. J. Plodinec, C. M. Jantzen and G. G. Wicks, "Stability of Radioactive Waste Glasses Assessed from Hydration Thermodynamics," **Scientific Basis for Nuclear Waste Management, VII**, G. L. McVay (ed.), 755-62 (1985).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

16. J. T. Carter, K. G. Brown, and D. F. Bickford, "DWPF Glass Composition Control Based on Glass Properties," **Proceedings - First International Conference on Advances in the Fusion of Glass**, D. F. Bickford, et al. (ed.), American Ceramic Society, Westerville, OH, chapter 20 (1988).

17. C. M. Jantzen, "Prediction of Glass Durability as a Function of Glass Composition and Test Conditions: Thermodynamics and Kinetics," **Proceedings - First International Conference on Advances in the Fusion of Glass**, D. F. Bickford, et al. (ed.), American Ceramic Society, Westerville, OH, chapter 24 (1988).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

TABLE 3.500.1 Specified composition for procurement of EA glass standard.*

Component	Target amount (wt %)	Allowed variation (% Rel. Std. Dev.)
Al_2O_3	3.67	5
B_2O_3	11.12	5
CaO	1.13	5
Fe_2O_3	8.08	See redox ratio**
FeO	0.89	See redox ratio**
K_2O	0.04	10
La_2O_3	0.41	10
Li_2O	4.28	5
MgO	1.66	5
MnO	1.34	5
Na_2O	16.71	5
NiO	0.61	10
SiO_2	48.95	5
TiO_2	0.71	10
ZrO_2	0.41	10

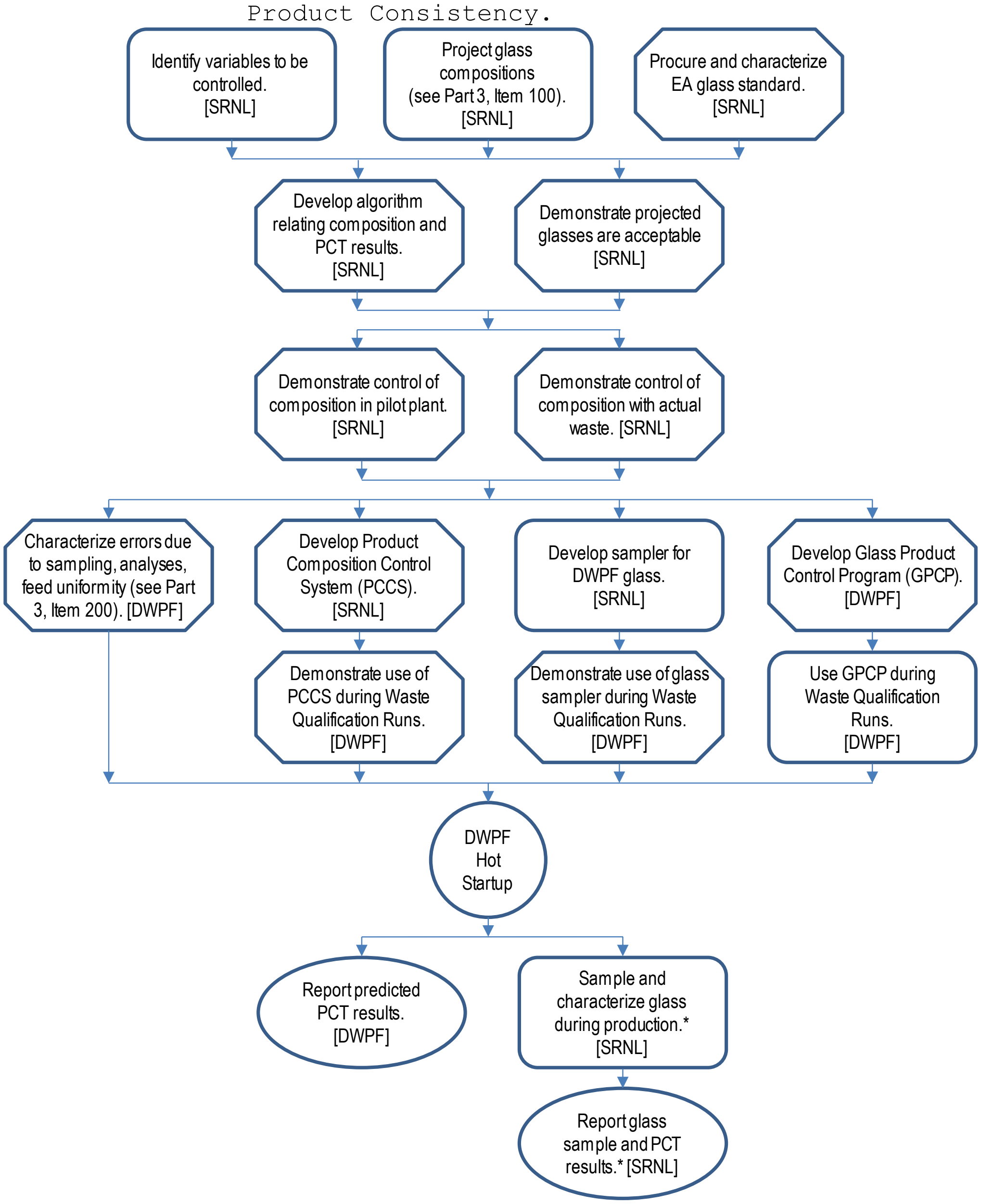
* The specific target composition is based on that of Table 3-1 of the DWPF EA. See the text.

** Fe2+/Fe3+ = 0.1 to 0.3 (Fe2+/Fe(total) = 0.09 to 0.23).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3 SPECIFICATION FOR PRODUCT CONSISTENCY

FIGURE 3.500.1 Tasks planned to satisfy Specification 1.3, Specification for Product Consistency.



*Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

1.4 SPECIFICATION FOR PHASE STABILITY

1.4.1 Phase Stability Information

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

(a) The glass transition temperature; and

(b) A time-temperature-transformation (TTT) diagram that identifies the duration of exposure at any temperature that causes significant changes in either the phase structure or the phase compositions.

The method to be used to obtain the required data shall be described in the WCP. 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 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.

Compliance Strategy

The transition temperatures and time-temperature transformation (TTT) diagrams will be determined for the set of projected glass compositions developed as described in Part 3, Item 100 (Thus, each sludge batch from the Tank Farm will constitute a waste type for compliance with this specification). Standard dilatometric methods (ASTM C336[1]) will be used to determine transition temperatures. Time-temperature-transformation (TTT) diagrams will be developed using methods previously employed by researchers at SRNL.[2-4] SRNL will then perform the DWPF Product Consistency Test on the heat-treated glasses.

As DWPF canistered waste forms move through the vitrification facility, no active measures are needed to assure that the specification is met, due to the low heat generation rate of the canistered waste forms.[5] During interim storage in the DWPF's Glass Waste Storage Buildings, the heat generation rate of DWPF canistered waste forms will not be great enough to exceed the specified temperature. In both GWSBs, air is circulated across the canisters' surfaces by natural convection to further ensure that the canisters do not exceed the specified temperature. The maximum temperature at time of shipment cannot be determined, since it is not known when shipment will occur. However, this temperature will be less than that during storage, due to radioactive decay. Any high temperature events which occur after initial cooldown will be documented in the Storage and Shipping Records.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.600.1. They are:

- Projection of glass compositions. This task is described in Part 3, Item 100.

- Determination of glass transition temperatures for each of the projected glasses.

- Documentation that the design of the DWPF's storage facility will maintain the maximum glass temperature below 400°C.

- Development of time-temperature-transformation diagrams for the projected glasses, and performance of the PCT on the heat-treated glasses.

Glass Transition Temperatures

As the projected glass compositions in Part 3, Item 100, are defined, the glass transition temperature, T_g, of each of the projected glasses will be determined, using the ASTM C336[1] standard test method. An example of a dilatometric curve for Design-Basis DWPF glass is shown in Figure 3.600.2. As can be seen in Table 3.600.1, the glass transition temperatures do not depend very strongly on composition. If, as is currently believed, the glasses listed in Table 3.600.1 are representative of the range of compositions of the DWPF canistered waste forms, then the transition temperatures of DWPF glasses will be in the range 440-460°C.

Glass transition temperature measurements will also be made using ASTM E1356[9], which uses differential scanning calorimetry to monitor the heat flow into and out of the glass sample.

Design of Glass Waste Storage Buildings

After filling, the temperatures of the canistered waste forms will not be routinely monitored in the DWPF. However, the canister surface temperature must be below 100°C before it is inserted in the Canister Decontamination Chamber (CDC). This prevents steam generation and provides a convenient operational definition of the end of initial cooldown.

Calculations have been performed[5,6] (using the HEATING5 finite element heat transfer code) which show that free-standing DWPF canistered waste forms will not exceed the specified temperature even at heat loadings 2-3 times higher (for GWSB#1 only) than that expected for DWPF glass (425 watts - see Table 3.600.2; the current Design-Basis heat loading is 710 watts). Thus, it is not possible to exceed the specified temperature (400°C) in the vitrification building after cooldown is completed because the canisters are essentially free-standing in ambient air.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

Calculations have been made for the GWSB#1 canister double stack option (i.e., doubles the number of canisters stored in GWSB#1) that show with a bounding 500 watts (upper) / 500 watts (lower) canister loading configuration, the maximum centerline glass temperatures are well below 400°C.[10] A canister handling strategy plan will be followed to ensure this bounding condition is not exceeded. Canisters currently planned to be double stacked in GWSB#1 do not exceed this 500 watts power loading. Calculations and experimental data will be provided in Volume 7 of the Waste Form Qualification Report (WQR) to show that at a surface temperature of 100°C, the centerline temperature of the glass is well below the specified temperature limit.

The canisters will be transported from the vitrification building to the interim storage facilities, called the Glass Waste Storage Buildings (GWSBs). Here, they can no longer be considered as free-standing objects in ambient air. However, the GWSBs have been designed so that the maximum temperature of the canistered waste forms cannot exceed the specified temperature under normal conditions. Calculations to establish this will be provided in the WQR. Centerline temperatures will be measured during the Startup Test Program which will validate the values of the heat transfer properties used in the calculations. As previously discussed for the GWSB#1 canister double stack option, the specified 400°C glass temperature limit will not be exceeded with the bounding 500 watts (upper) / 500 watts (lower) canister loading configuration.

It is not possible to determine a maximum temperature at time of shipment, since it is not known when shipment will occur. However, the maximum temperature canistered waste forms will experience is at the time of initial storage, due to radioactive decay. Thus, these maximum temperatures will be provided as conservative estimates of the temperature at time of shipment. An analysis of the design of the GWSBs will be performed to establish that the glass cannot reach or exceed the specified temperature of 400°C under normal conditions. Initial estimates of the temperature during storage indicate that canister heat loads of greater than 3 kilowatts (> 4X the maximum projected heat generation rate of DWPF canistered waste forms) would be necessary to exceed 400°C during storage. Any actions that are necessary to ensure that the glass temperature remains below 400°C under accident conditions will also be described.

Time-Temperature-Transformation Diagrams and PCT Testing

Time-temperature transformation diagrams for each of the projected glasses will be developed. The effects of changes of phase composition on the results of the Product Consistency Test (PCT) will be determined by testing all heat-treated samples.

TTT diagrams of glasses with specific frit and waste compositions have already been developed. In general, it has been found[7,8] that the durability of DWPF glass depends more strongly on the glass-former composition, than on the sludge composition. Over the range of expected glass compositions and canister cooling conditions, these studies also indicate little effect of crystalline content on glass durability.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

Qualification of Future Glass Compositions

When future waste compositions are identified, glasses will be formulated for them which will satisfy the criterion in Part 3, Item 500. These glasses will be subjected to the same testing (glass transition temperature, TTT determinations, PCT results) as is currently being done for projected compositions developed as described in Part 3, Item 100. The results of these studies will be submitted as an addendum to the WQR.

The heat generation rate of future waste compositions will also be calculated from the projected radionuclide inventory. If the heat generation rate could cause the maximum glass temperature to exceed the specified storage temperature, the WQR addendum will also detail those actions which will be taken to prevent this from happening.

Documentation

The Waste Form Qualification Report (WQR) Volume 7 will include the glass transition temperatures of the projected glasses. The WQR will also include time-temperature-transformation diagrams for each of the projected glasses, and PCT results for all heat-treated samples.

The Storage and Shipping Record for each canistered waste form will certify, if true, that the maximum waste glass temperature experienced during storage of each canistered waste form has been below 400°C. If true, the Storage and Shipping Record for each canistered waste form will also certify that after initial cooldown, no unusual events occurred which would cause the maximum temperature of the canistered waste form to exceed 400°C, during handling and storage at the DWPF. If any such non-conforming condition has occurred, the Production Records or Storage and Shipping Records (depending on when the event occurred) will document the occurrence, and identify the canister as a potential non-conformance. In this case, the procedure in Part 6, Item 300, will be followed.

References

1. **Annual Book of ASTM Standards, 15.02**, “Annealing Point and Strain Point of Glass by Fiber Elongation,” American Society for Testing and Materials (1991).

2. C. M. Jantzen, D. F. Bickford, D. G. Karraker and G. G. Wicks, "Time-temperature-transformation kinetics in SRL waste glass**," Advances in Ceramics -Nuclear Waste Management, 8**, W. A. Ross and G. G. Wicks (eds.), 30-38 (1984).

3. D. F. Bickford and C. M. Jantzen, "Devitrification Behavior of SRL Defense Waste Glass," **Scientific Basis for Nuclear Waste Management,** VII, G. L. McVay (ed.), Elsevier, NY, 557-66, (1984).

4. D. F. Bickford and C. M. Jantzen, "Devitrif. of Defense Nuclear Waste Glasses: Role of Melt Insolubles," **J. Non-Cryst. Solids, 84,** 299-307 (1986).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

5. R. G. Baxter, **Defense Waste Processing Facility Wasteform and Canister Description,** USDOE Report DP-1606, Revision 2, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC 29808 (1990).

6. M. H. Tennant, "Temperatures Generated by Underground Storage of Defense Waste Canisters," **Scientific Basis for Nuclear Waste Management, II,** C. J. M. Northrup (ed.), 825-32 (1980).

7. C. M. Jantzen and D. F. Bickford, "Leaching of Devitrified Glass Containing Simulated SRP Nuclear Waste**," Scientific Basis for Nuclear Waste Management, VIII,** C. M. Jantzen, et al. (ed), Materials Research Society, Pittsburgh, PA, 135-46 (1985).

8. N. E. Bibler, "Characterization of borosilicate glass containing Savannah River Plant radioactive waste," **Glastekn. Ber., 56K,** 736-41 (1983).

9. **ASTM Standard E1356**, "Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry," American Society for Testing and Materials (2003).

10. J. E. McAllister, Jr., P. A. LaVigne, "Double Stacking of Canisters in the Glass Waste Storage Building #1," M-CLC-S-00819, Revision 0, Savannah River Site, Aiken, SC (2015).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

TABLE 3.600.1 Glass Transition Temperatures for SRNL Simulated Waste Glasses.

Composition*	Glass Transition Temperature
Design-Basis glass	459°C
165/Purex waste	448°C
165/HM waste	451°C
131/Design-Basis waste	460°C

* 131 and 165 refer to glass-former compositions used by SRNL. Frit 165 is similar to current DWPF glassformer compositions. Frit 131 represents an extreme composition, high in alkali and boron. Purex and HM refer to two hypothetical waste compositions (see Part 3, Item 100).

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

TABLE 3.600.2 Temperatures of Free-Standing Canistered Waste Forms.

Watts	Surface Temp.(°C)	Centerline Temp.(°C)	Surrounding Air Temp.(°C)
425*,**	34	50	20
510**	54	71	38
690**	58	89	38
1000	66	120	38

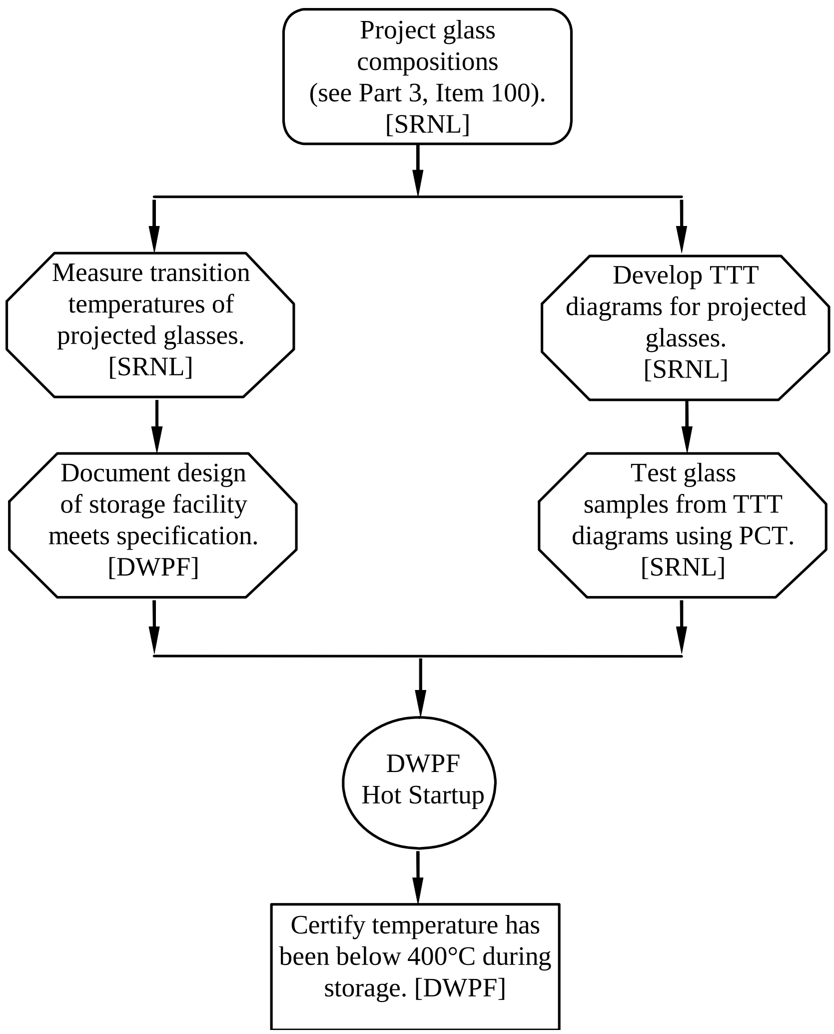
* Expected average value for DWPF canistered waste forms.

** Earlier values used for design purposes.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

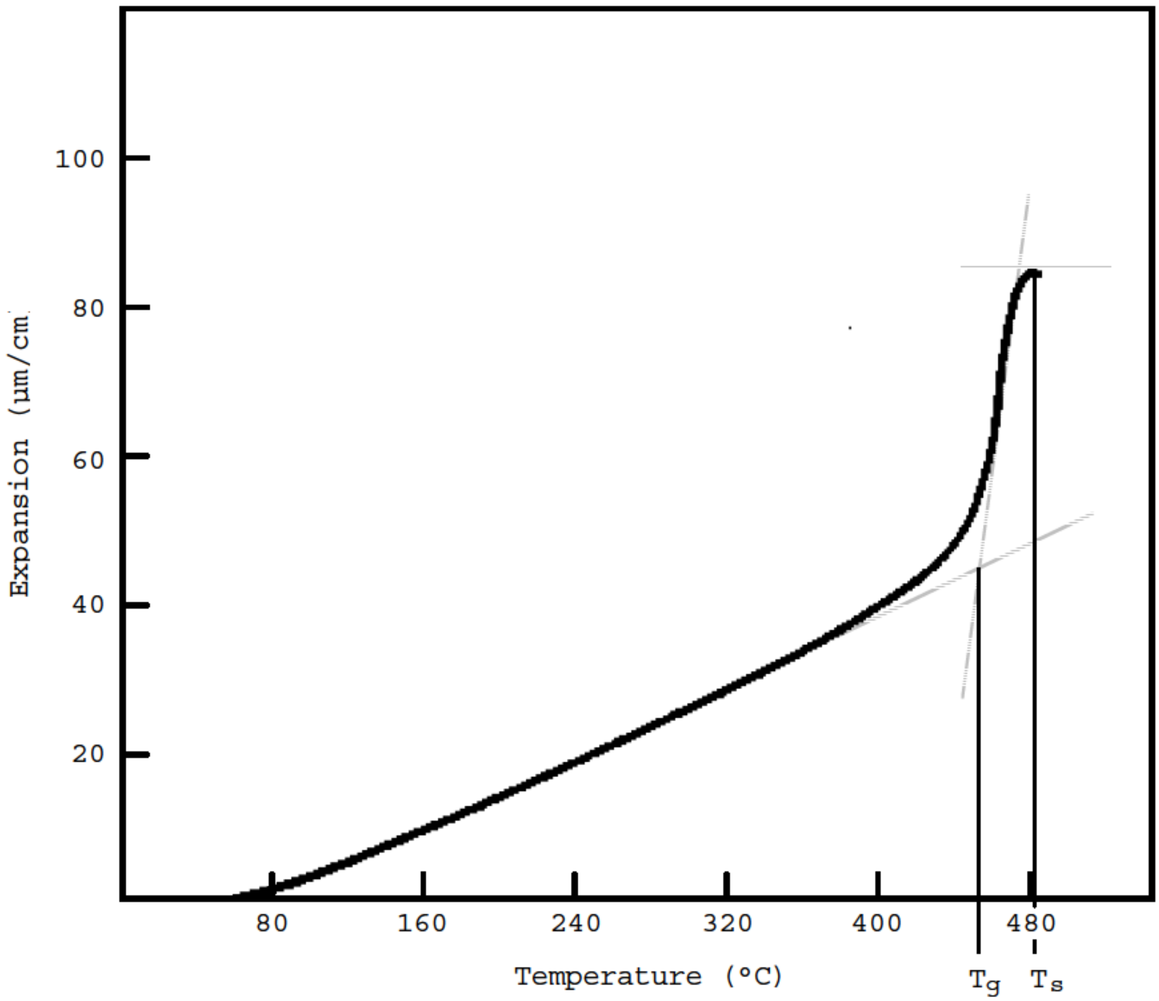
FIGURE 3.600.1 Tasks planned to satisfy Specification 1.4, Specification for Phase Stability.



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR PHASE STABILITY

FIGURE 3.600.2 Dilatometric Determination of T_g for Design-Basis DWPF glass.



Transition Temperatures: T_g, Transformation Temperature = 459°C
T_s, Softening Temperature = 483°C

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.5 HAZARDOUS WASTE SPECIFICATION

1.5 HAZARDOUS WASTE SPECIFICATION

The Producer shall determine and report to DOE/RW the presence or absence of any hazardous waste listed in 40CFR261.31 through 40CFR261.33*, in the waste or in any feed stream proposed for storage and disposal. Any RCRA-listed component in the waste shall require the Producer to petition EPA and receive exemption to delist the waste.

The Producer shall perform the appropriate tests and procedures, described in 40CFR261.20 through 40CFR261.24, using samples from production runs or prototypical to determine if the waste that will be received by DOE/RW, for transportation and disposal, has hazardous characteristics. Any waste that is shown to have hazardous characteristics shall be treated to remove such characteristics.**

The Producer shall report and certify in the WQR that the waste is not hazardous, including the absence of any listed components. The characteristic testing methods to be used shall be described in the WCP and the results documented in the WQR. Any modification to these methods needs prior approval from DOE/RW.

Compliance Strategy

The DWPF glass waste form is not hazardous listed waste based on a review that was conducted to determine if listed hazardous wastes have been discarded in the high-level waste tanks. To demonstrate that the glass waste form is not characteristic hazardous waste, the DWPF will perform the Toxic Characteristic Leaching Procedure (TCLP)[1] on the set of projected glass compositions described in Part 3, Item 100 and on the Environmental Assessment (EA) glass, each doped with hazardous metals. This set of projected glasses should bound the performance of any glass produced in the DWPF while the EA glass represents an extreme composition.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.700.1. They are:

- Projection of glass compositions. This task is described in Part 3, Item 100.

- Documentation that the DWPF waste form is not hazardous listed waste.

- Demonstration that the DWPF waste form is not characteristic hazardous waste by performing the Toxicity Characteristic Leaching Procedure[1] (TCLP).

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* Code of Federal Regulations, Protection of Environment, 40 Parts 260 to 299, 40CFR261.31 through 40CFR261.33.
** Code of Federal Regulations, Protection of Environment, 40 Parts 260 to 299, 40CFR261.20 through 40CFR261.24.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.5 HAZARDOUS WASTE SPECIFICATION

DWPF Waste Stream

The high level waste tanks at SRS primarily contain wastes from reprocessing irradiated nuclear fuels. These tanks also contain small quantities of waste generated by two laboratories. A review of practices and procedures for waste disposal to the high-level waste tanks has been conducted. Each category of listed waste was considered; hazardous waste from non-specific sources, hazardous wastes from specific sources, and discarded commercial chemical products, off-specification species, container residues, and other spill residues of these commercial chemical products. The review concluded that the SRS high-level waste tanks do not contain listed wastes. Thus, the DWPF glass waste form is not hazardous listed waste. This review will be provided in WQR Volume 13.

Toxicity Characteristic Leaching Procedure

The Toxicity Characteristic Leaching Procedure (TCLP) is an EPA-mandated test for determining whether a waste form retards the release of hazardous metals (i.e. arsenic, barium, cadmium, lead, mercury, nickel, selenium, and silver) from a waste form. In order to demonstrate that the DWPF product is not characteristic hazardous waste, samples of the projected glass compositions described in Part 3, Item 100, along with samples of the Environmental Assessment glass[2], will be doped with two different levels of hazardous metals of interest (e.g. silver, barium, lead, cadmium, chromium, and selenium). Samples of the projected compositions must be doped with hazardous metals since they were not included during the fabrication of the simulated waste glasses. Arsenic and mercury will not be considered since arsenic is not found in SRS waste streams and mercury is removed during chemical processing. Any residual mercury remaining in the melter feed will be volatilized into the melter offgas system during melting. The dopant levels will simulate the amount of metal expected to be found in the actual waste as well as an extreme case of approximately 3 times the expected level. The glass will be melted and quenched in order to provide a sample for TCLP. The TCLP will be performed by a certified laboratory. The TCLP results must be less than the RCRA limits for leaching of hazardous metals as listed in 40CFR261.24(b) Table 1 in order to verify that DWPF waste glass is not a characteristic hazardous waste. The organic materials listed in this table will not be considered since organic materials will not survive the vitrification process (see Part 5, Item 250).

SRTC will ensure that the levels of hazardous metals in the actual waste do not exceed those levels tested. This will be accomplished during the qualification of waste portion of the Glass Product Control Program described in Volume 6 of the Waste Form Qualification Report.

Documentation

Volume 13 of the Waste Form Qualification Report (WQR) will provide the documentation to show that the SRS high-level waste tanks do not contain listed waste and thus the DWPF waste form is not hazardous listed waste. The WQR will also include the results of the TCLP testing of the doped simulated samples.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.5 HAZARDOUS WASTE SPECIFICATION

References

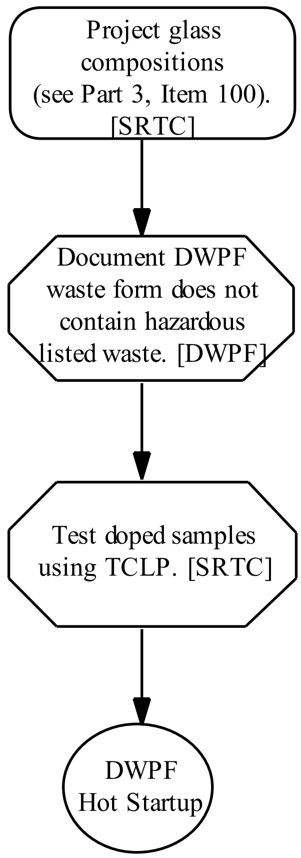
1. Federal Register Rules and Regulations, "Toxicity Characteristic Leaching Procedure," Appendix 1, Part 268, Vol. 51, No. 216, November 11, 1986.

2. U.S. Department of Energy, **Environmental Assessment Waste Form Selection for SRP High-Level Waste**, USDOE Report DOE-EA-0179, July 1982.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.5 HAZARDOUS WASTE SPECIFICATION

FIGURE 3.700.1 Tasks planned to satisfy Specification 1.5, Hazardous Waste Specification.



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.6 IAEA SAFEGUARDS REPORTING FOR HLW SPECIFICATION

The Producer shall report the following in the Production Records:

(1) The total and fissile uranium and plutonium content of each canister in grams.

(2) The concentration of plutonium in grams per cubic meter for each canister.

(3) The ratio by weight of the total element of the following isotopes: U-233, U-234, U-235, U-236, U-238, Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242.

Compliance Strategy

The strategy for determining the uranium and plutonium isotopes of DWPF glass is similar to that for the radionuclide inventory during production (Part 3, Item 400). It uses the same approach of reporting the required information on a macrobatch basis. The only difference in the strategy is the units used to report the concentrations. The DWPF will determine the average concentrations of the uranium and plutonium isotopes by a feed-to-glass correlation (see Part 3, Item 400).

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.800.1 and are the same as those used to satisfy specification 1.2.2 (see Part 3, Item 400). These are:

- Development of methods to calculate the concentration of radionuclides by feed-to-glass correlation.

- Estimation of the errors in the reported radionuclide inventory.

Determining Concentration of Plutonium and Uranium Isotopes

Most of the uranium and plutonium isotopes are present in the SRS waste in small quantities. Thus, these isotopes cannot be measured in the DWPF analytical laboratory. The measurements of these isotopes will be based on analyses of Tank Farm Samples in the same manner described in Part 3, Item 400. Some of the minor isotopes are not reportable based on specification 1.2.2. However, the same methods as described in Part 3, Item 400 will be used for these minor isotopes.

In order to report the isotopes with the required units, the following approach will be used. A detailed description of the calculations will be presented in Volume 4 of the Waste Form Qualification Report.

- Total Uranium and Plutonium Contents. The total uranium and plutonium contents, determined from the analyses of Tank Farm samples, will be averaged

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.6 IAEA SAFEGUARDS REPORTING FOR HLW SPECIFICATION

to obtain an average wt% value for the macrobatch. The wt% value will be multiplied by an average glass weight per canister to obtain the total uranium and plutonium contents per canister. The total plutonium content will be divided by an average glass volume to obtain the plutonium content per canister in grams/m^3.

- Ratio by weight of uranium and plutonium isotopes. The individual uranium and plutonium isotopes will be determined from the DWPF measurements or analyses of Tank Farm samples. These values will be divided by the total uranium or plutonium content described above to obtain the ratio by weight.

Estimates of Error

The sources of error for the IAEA reporting requirements are the same as those described in Part 3, Item 400 for reporting radionuclide inventory. Each of these sources of error will be characterized and the results reported in Volume 4 of the Waste Form Qualification Report.

Glass Sampling

At least one glass pour stream sample will be taken by DWPF during the processing of each sludge batch, analyzed as necessary and archived at the SRNL Shielded Cells Facility. These samples may be characterized should additional testing requirements be identified in the future but are no longer required for batch sampling confirmation.

Documentation

Volume 4 of the Waste Form Qualification Report will include a report on the methods to be used to determine the uranium and plutonium isotopes during production. The precision and accuracy of the methods used, based upon demonstrations in the SRNL Shielded Cells Facility, and analyses of samples from the Tank Farm, will also be reported. The Waste Form Qualification Report will also contain estimates of the errors of calculational algorithms used.

The Production Record for each canistered waste form will include the following:

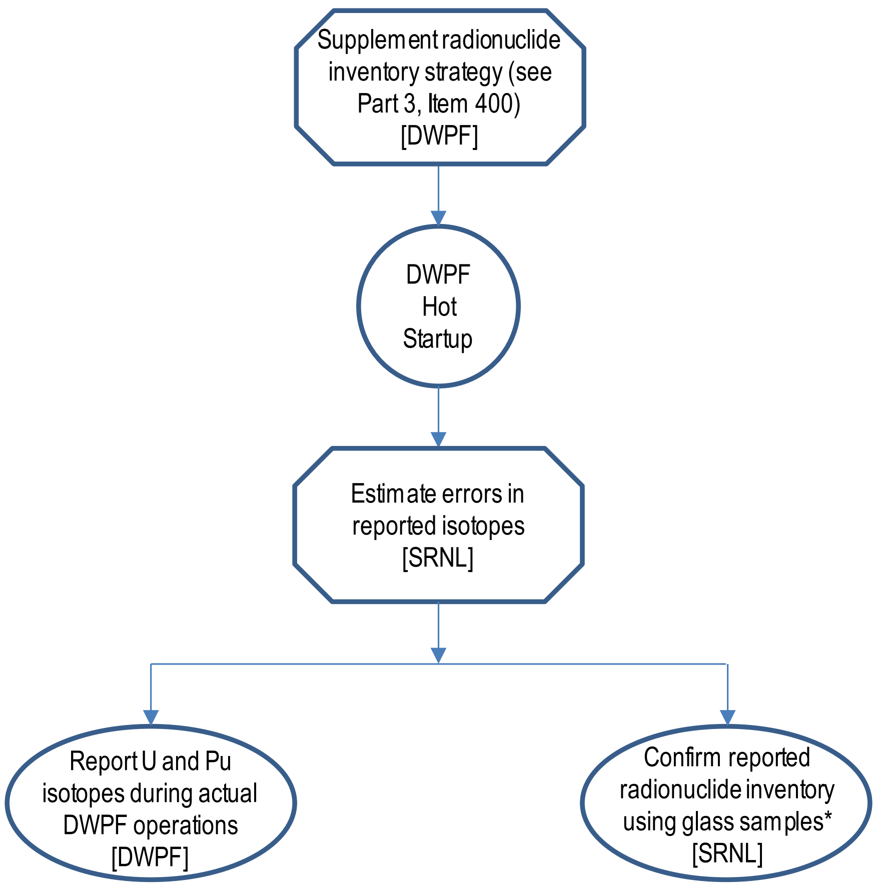
- Total uranium and plutonium content per canister in grams
- Mass ratios of the required uranium and plutonium isotopes
- Total plutonium content per canister expressed as grams/m^3

This information will be reported as a single value for each canister in the entire macrobatch.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.6 IAEA SAFEGUARDS REPORTING FOR HLW SPECIFICATION

FIGURE 3.800.1 Tasks planned to satisfy Specification 1.6, IAEA Safeguards Reporting for HLW Specification.



*Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

2.1 MATERIAL SPECIFICATION

The waste form canister, the canister label, and any secondary canister applied by the producer shall be fabricated from austenitic stainless steel. Applicable ASTM* or other nationally recognized alloy specifications and the compositions of the canister materials, the canister label materials, any secondary canister material, and any filler materials used in welding shall be included in the WCP. Documentation of compliance shall be included in the Production Records.

Compliance Strategy

The DWPF will ensure that the materials in the procured canister assembly meet the specification through a combination of component specifications, and inspections to ensure that these component specifications are met. Procurement documents for the DWPF canisters, including canister labels, require that all material used in fabrication of the canisters shall meet the compositional requirements of the appropriate ASTM or ASME designations (or equivalent). All of these materials are austenitic stainless steel in nature. The procurement documents also require that material certifications be provided to DWPF for the metal heat used for fabrication of each component. The canisters are to be inspected by a Supplier Surveillance Representative (SSR) prior to shipment to DWPF. This inspection includes verification of documentation on the compositions of canister materials.

At the present time, the DWPF has reserved space in the welding cell for equipment to package a faulty glass-filled canister in a secondary canister. Equipment and process development have been suspended because of the very unlikely nature of the need for such equipment. If, at a later date, it is determined that a secondary canister is needed, equipment and process development will be re-initiated. Information on the secondary canister would then be supplied in a revision to the WQR. The material composition would be reported in the WCP. Any secondary canister would require use of the same materials specified above.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 4.100.1. These are:

- Specification of only austenitic stainless steel materials in the canister procurement documents.

- Delivery to the DWPF of documented certification that these material specifications have been met, by the vendor.

- Verification that only austenitic materials have been used.

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* Annual Book of ASTM Standards, American Society of Testing and Materials, Easton, MD (1987)

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

Specification of Canister Materials

The current procurement specifications for the canisters require that the various parts of the canister assembly be fabricated from the following materials.

Cylinder	ASTM A240 Type 304L stainless steel
Nozzle and Flange	ASTM A965 Type F304L stainless steel (formerly A336)
Tapered Plug	ASTM A240 Type 304L stainless steel
Neck Sleeve	ASTM A479 Type S21800 stainless steel (Nitronic 60)
Heads	ASTM A240 Type 304L stainless steel
Weld Plug	ASTM A240 Type 304L stainless steel
Repair Plug	ASTM A479 Type S21800 stainless steel (Nitronic 60)
Repair Cap	ASTM A240 Type 304L stainless steel
Weld Filler Metal (also used for label)	ANSI/AWS A5.9 ER308L or ASME SFA5.9 ER308L stainless steel

The alloy compositions corresponding to these specifications are given in Tables 4.100.1 to 4.100.4. Canisters used in non-radioactive equipment development and testing at SRTC have been procured to these specifications.

Documented Certification and Verification

The canister procurement specifications require that the vendor of the canister assembly supply material certifications to DWPF for each heat of metal used. An SRS representative at the vendor's location will perform verification activities to ensure that only specified materials were used. These activities will be described in Volume 8 of the Waste Form Qualification Report.

Documentation

The WAPS require that the DWPF certify that the canisters are fabricated from the materials identified in the Waste Form Compliance Plan. The Waste Form Qualification Report will reference the canister procurement specifications, and will describe the verification activities which will be performed. The Production Records will reference the procurement documents for each canister. The detailed procurement documents will include the actual specifications, purchase orders, vendor and heat identification records, certificates of analyses, and inspection records. If these values are outside the specified ranges, the canister will be identified as a nonconforming item. Its disposition will be in accordance with the procedure outlined in Part 6, Item 300.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

TABLE 4.100.1   Required chemical composition of ASTM A240 Type 304L stainless steel.

Component	Amount (wt%)
Carbon	0.030 maximum
Manganese	2.00 maximum
Phosphorus	0.045 maximum
Sulfur	0.030 maximum
Silicon	0.75 maximum
Chromium	18.00 - 20.00
Nickel	8.00 - 12.00
Other elements	Nitrogen - 0.10 maximum

Reference: Annual Book of ASTM Standards, 1.03, American Society for Testing and Materials, Easton, MD, 62 (1990).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

TABLE 4.100.2 Required chemical composition of ASTM A965 Type F304L stainless steel.

Component	Amount (wt%)
Carbon	0.030 maximum
Manganese	2.00 maximum
Phosphorus	0.045 maximum
Sulfur	0.030 maximum
Silicon	1.00 maximum
Chromium	18.00 - 20.00
Nickel	8.00 – 12.00
Other elements	No specification

Reference: Annual Book of ASTM Standards, 1.05, ASTM International, West Conshohcken, PA (January 2011).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

TABLE 4.100.3 Required chemical composition of ASTM A479 Type S21800 stainless steel (Nitronic 60).

Component	Amount (wt%)
Carbon	0.10 maximum
Manganese	7.00 - 9.00
Phosphorus	0.060 maximum
Sulfur	0.030 maximum
Silicon	3.50 - 4.50
Chromium	16.00 - 18.00
Nickel	8.00 - 9.00
Other elements	Nitrogen 0.08 - 0.18

Reference: Annual Book of ASTM Standards, 1.05, American Society for Testing and Materials, Easton, MD, 361 (1990).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

TABLE 4.100.4 Required Chemical Composition of ASME SFA5.9 ER308L and ANSI/AWS A5.9 ER308L Stainless Steel.

	Amount (wt%)*	
Component	ANSI/AWS A5.9[1]	ASME SFA5.90[2]
Carbon	0.03 maximum	0.03 maximum
Manganese	1.0 - 2.5	1.0 - 2.5
Phosphorus	0.03 maximum	0.03 maximum
Sulfur	0.03 maximum	0.03 maximum
Silicon	0.30 - 0.65	0.30 - 0.65
Chromium	19.5 - 22.0	19.5 - 22.0
Nickel	9.0 - 11.0	9.0 - 11.0
Molybdenum	0.75 maximum	0.75 maximum
Copper	0.75 maximum	0.75 maximum
Other elements	No specification	

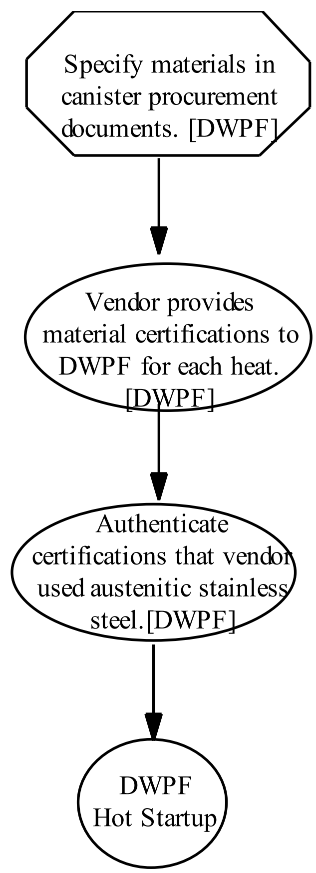
* Additional constraint on weld filler material composition (per procurement specification):
$1.40 < (Cr)eq/(Ni)eq < 1.67$
where $(Cr)eq = \%Cr + 1.5\% Si + \%Mo + 0.5\% Nb$
and $(Ni)eq = \%Ni + 0.5\%Mn + 30\%C + 30\%N$

References: 1. **American National Standards Institute/American Welding Standard**, Section A5.9.
2. **ASME Boiler and Pressure Vessel Code, Section II, Part C**, American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (1989).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

FIGURE 4.100.1 Tasks planned to satisfy Specification 2.1, Material Specification.



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

2.2 FABRICATION AND CLOSURE SPECIFICATION

The canister fabrication and closure methods shall be identified in the WCP. The outermost closure shall be leaktight to less than $1x10^{-4}$ atm-cc/sec helium. The method for demonstrating compliance shall be described by the producer in the WCP. The WQR shall provide evidence that the canister fabrication and closure methods are capable of complying with the leaktightness criterion. Compliance during production shall be documented in the Production Records.

Compliance Strategy

The DWPF will comply with this specification by ensuring that both the canister itself, and the canister closure weld made after the canister is filled with glass, are of high integrity. The integrity of the canister itself will be ensured by specifications on the components and on the method of fabrication of the canister assembly, and verification to ensure that these specifications are met. The integrity of the final closure weld applied in the DWPF will be ensured by close control of the welding process.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 4.200.1. They are:

- Specification of the methods of fabrication in the canister procurement specifications.
- Verification that the specifications have been met by the vendor.
- Development of the resistance welding process for closing the canister.
- Performance of a parametric study with the DWPF welder to determine the operating limits for the welding process. This study will be performed as part of the Startup Test Program.
- Performance of studies to verify the leaktightness of welds produced under production conditions within the operating limits. This study will also be performed as part of the Startup Test Program.

Methods of Fabrication

The canister is fabricated from 304L stainless steel rolled plate, a dished bottom head, a domed top head, and a head nozzle containing a combined lifting and welding flange. These components are welded together to form a canister 300 cm (118 in) high.

The specifications for procurement of the DWPF canister assembly detail the requirements for fabrication. The main cylinder is to be fabricated from rolled plate which has been hot-rolled, annealed, and pickled. Canister heads (top and bottom) are to be hot-rolled, annealed, and pickled, formed into shape, then solution annealed, and reformed. The nozzle, tapered plug, and

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

the Nitronic 60 sleeve are all to be machined to tolerances. The canister nozzle, top head, cylinder, and bottom head will then be welded together.

Verification

As currently specified, all welding, welding procedure qualifications, repair, electrodes, and welder performance tests used in the fabrication of the canisters, are to be performed in accordance with ASME Section IX, Summer 1989 Addenda - Welding and Brazing Qualifications[1], unless otherwise specified in the canister procurement document. The canister fabrication welds are to be made according to drawing and procedural specifications. A representative of DWPF will approve all weld procedures and verify welder(s) qualification prior to fabrication. A Supplier Surveillance Representative will verify that the procedures have been followed by inspections conducted at the vendor's shop.

After fabrication, all full penetration butt welds will be subjected to a radiographic examination per ASME Section V.[2] Evaluation will be in accordance with UW-51 of ASME Section VIII.[3]

Each canister will be pressure tested by the vendor. The pressure test will use clean, dry, oil-free air or nitrogen at 187.5-193.0 psig for one hour. After the pressure test each canister will also be helium leak tested by the vendor. The DWPF has imposed a leak rate criterion of 1×10^{-7} atm·cc/sec air equivalent on the canister vendor. This limit is more stringent than the WAPS limit of 1×10^{-4} atm·cc/sec helium to ensure that the canistered waste form can meet the WAPS limit. Only canisters with leak rates less than 1×10^{-7} atm·cc/sec air equivalent will be accepted from the vendor.

Canisters received by the DWPF will be inspected for gross damage, surface defects, and surface cleanliness. The canister procurement specifications[4] and DWPF inspection procedures will be documented in the Waste Form Qualification Report (WQR).

Development of the Resistance Welding Process

The resistance welding process has been selected as the final closure method for DWPF canistered waste forms. This technique was chosen after consideration of seven alternative processes including gas tungsten arc, gas metal arc, plasma arc, thermite, electron beam, laser beam and friction welding. Resistance welding was selected because of its reliable high weld quality, its tolerance to wide variations in process parameters, and its relatively simple equipment needs.[5]

In this process, a nominal 12.89 cm (5.07 in) diameter, 1.27 cm (0.5 in) thick, 304L stainless steel plug is placed in the canister neck. A ram forces the plug down into the neck while an electric current is passed through the narrow (high resistance) contact between the canister neck and the plug. The plug is chamferred so that when the welding ram is lowered, the plug will be self-leveling and self-centering. The current softens (but does not melt) the metal at the contact so that a solid state weld is formed between the plug and the canister nozzle. The approximate weld conditions are a force on the ram of 400,000 newtons (90,000 lb), and a direct current of 250,000 amps for 1.5 seconds.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

Weld tensile strength and leak measurements have been made on upset resistance welds under a wide variety of surface conditions. An upset resistance weld with a nominal 12.89 cm diameter plug and a machined canister neck is leaktight to at least 10^{-8} atm·cc/sec helium (detection limit) for a hydrostatic test pressure of 34 MPa (5,000 psi).

Parametric Study of Weld Parameters

Considerable testing of experimental welding equipment has already been completed. These tests have shown that the parameters which affect weld quality are: the cleanliness and condition of the surfaces to be welded, the levelness of the weld plug in the nozzle, the force used for welding, the current used for welding, and the duration of the weld. These tests indicate that the range of conditions which produce acceptable welds is much wider than the range of expected operating conditions in the DWPF. Burst tests of welded specimens, and destructive examination of experimental welds, have both shown that the welds produced in the DWPF should be of comparable strength to the base metal. These tests will be repeated using the actual DWPF equipment. These parametric studies, which will be performed during the Startup Test Program (Appendix 1.200.3), will vary the key weld parameters (time, current, force) in a factorial manner in order to define the operating limits for the actual process equipment. Simulated (dummy) welds will be made, helium leak tested, pressurized to rupture (burst testing), and characterized microstructurally.

Verification of Operating Limits

During the Startup Test Program, the welder will be qualified to ASME Section IX requirements. Simulated (dummy) welds will again be made, tested, and characterized microstructurally. The acceptability of canister welds produced within the operating parameters selected for use in the DWPF will also be verified, with the DWPF operating procedures, operators, and the process equipment. This testing will demonstrate that maintaining the weld parameters (force, current, time) within operating limits will produce welds that meet this specification. The results of this testing will be reported in Volume 8 of the WQR.

During production, the quality of the final closure weld in the DWPF will be assured through the following: specification and inspection of the weld plug and canister nozzle before welding to ensure a good surface for welding, and control of the welding process parameters (force, current, and time).

At the present time, the DWPF has reserved space in the welding cell for equipment to package a faulty glass-filled canister in a secondary canister. Equipment and process development have been suspended because of the very unlikely nature of the need for such equipment. If, at a later date, it is determined that a secondary canister is needed, equipment and process development will be re-initiated. Information on fabrication and closure of the secondary canister would then be supplied in a revision to the WCP. It is likely that a different closure process would be needed.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

Documentation

Volume 8 of the Waste Form Qualification Report will reference the canister procurement specifications. Volume 8 will also include a report on the parametric testing of weld conditions and associated leak rates, and validation of the parametric testing during the Startup Test Program.

The Production Record (Appendix 1.200.1) for each canistered waste form will certify that the canister components and the entire canister assembly were fabricated according to approved drawings and procedures, and meet the procurement specifications.

The Production Record will also certify the integrity of the final closure weld made in the DWPF. The Production Records will report the force, current, and duration of application of the current as recorded by the computer collecting the data from the DWPF welder. If these values are outside the range of parameters which have been shown to produce a leaktight weld, the canister weld will be identified as a nonconforming item. Its disposition will be in accordance with the procedure outlined in Part 6, Item 300.

References

1. **ASME Boiler and Pressure Vessel Code, Section IX, Part QW,** American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (1989).

2. **ASME Boiler and Pressure Vessel Code, Section V,** American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (1989).

3. **ASME Boiler and Pressure Vessel Code, Section VIII,** American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017, (1989).

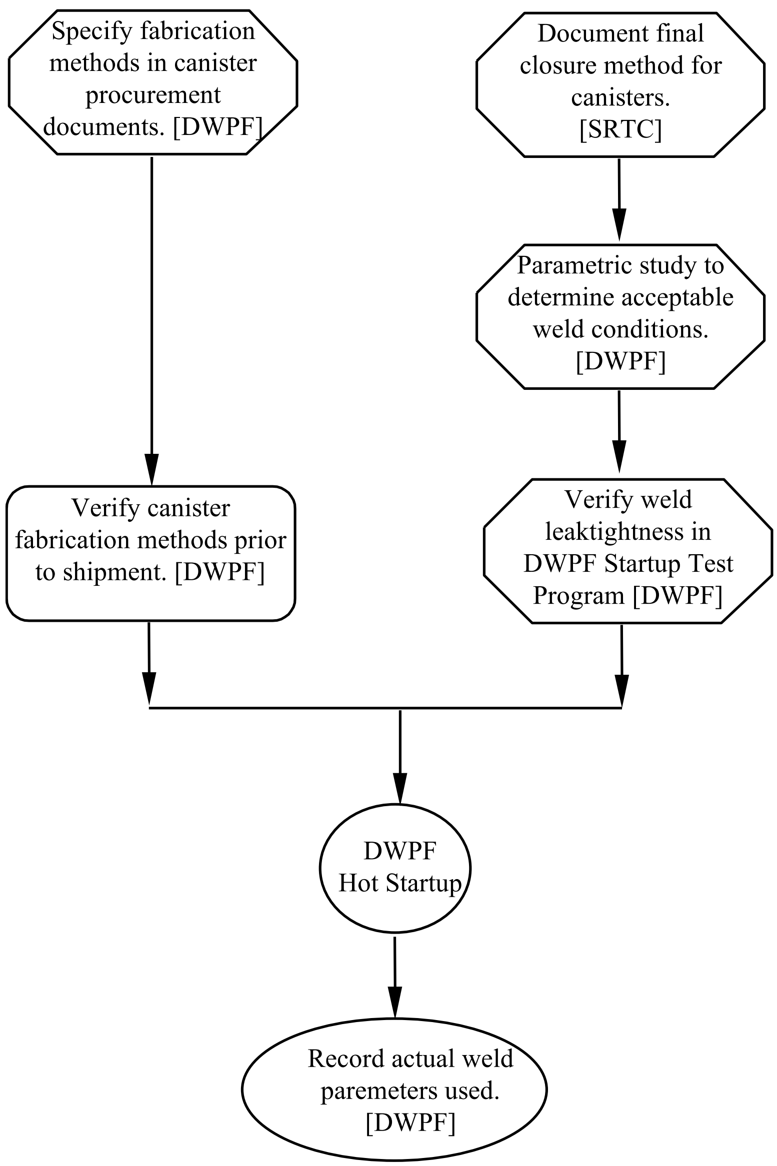
4. R. E. Erickson to R. Schepens memorandum, “Defense Waste Processing Facility Canister Specification Changes,” (1998).

5. B. J. Eberhard, and J. W. Kelker, "High Current Resistance Welding of Nuclear Waste Canisters," **Welding Journal, 61(6)**, 15-9 (1982).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

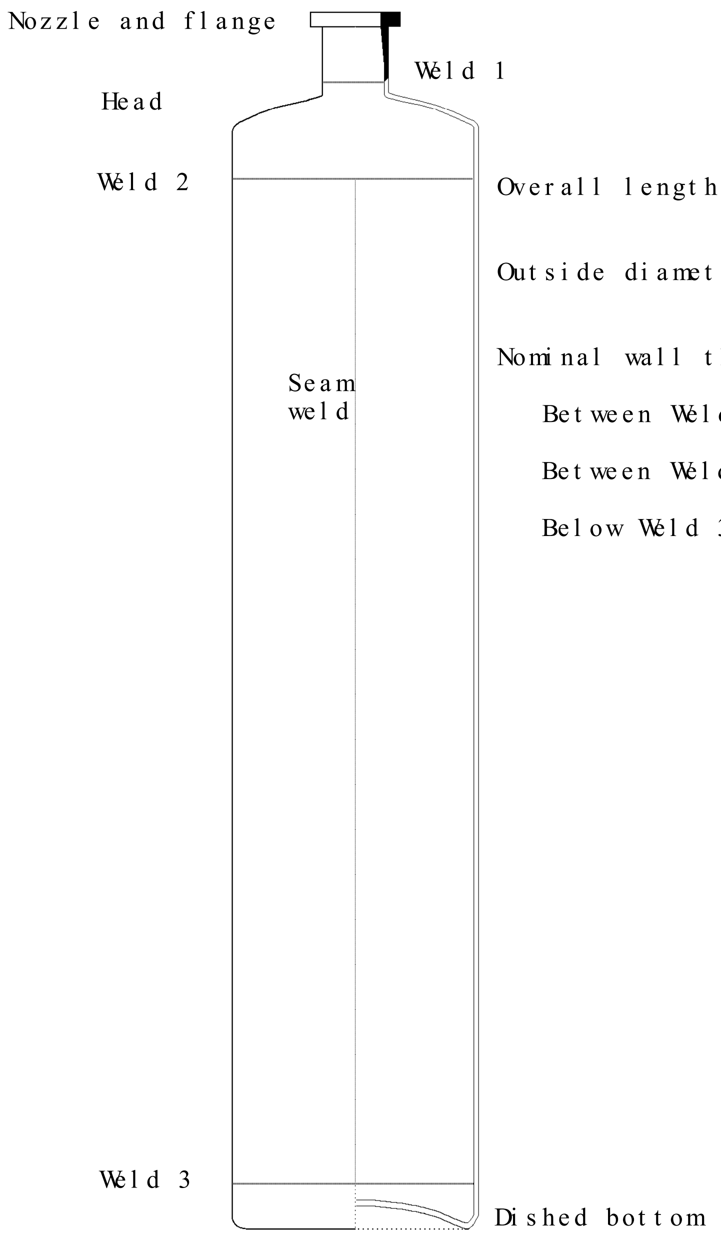
FIGURE 4.200.1 Tasks planned to satisfy Specification 2.2, Fabrication and Closure Specification.



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

FIGURE 4.200.2 Components and overall nominal dimensions of the DWPF canister.



Overall length 118.0 in (299.72 cm)

Outside diameter 24.0 in (60.96 cm)

Nominal wall thickness:

Between Weld 1 and 2	0.63 in (1.59 cm)
Between Weld 2 and 3	0.37 in (0.95 cm)
Below Weld 3	0.50 in (1.27 cm)

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

2.3 IDENTIFICATION AND LABELING SPECIFICATION

2.3.1 Identification

The Producer shall assign a unique alphanumeric identifier to label each outermost canister that is produced. This label shall appear on the canistered waste form and on 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 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.

The label shall be designed to be legible after filling and storage at the Producer's facility and shipment to the repository. The label shall be an integral part of the canister (e.g. embossed) and shall not impair the integrity of the canister.

Compliance Strategy

The identification code planned for the canistered waste forms is a six digit alphanumeric code consisting of the letter "S" followed by five numbers. The label lettering will conform to the specification.

The DWPF canister label is made of welding rod bead-welded directly to the canister surface. The welding rod is the same austenitic stainless steel composition used for canister assembly, to assure compatibility with the canister. This labeling technique has been shown suitable by fabricating sample labels, frit blasting them in a manner similar to that in the DWPF, and then establishing that they are still easily visible under process viewing conditions.

Implementation

The tasks being performed to satisfy this specification are outlined in Figure 4.300.1. As noted in the Compliance Strategy, the alphanumeric code for DWPF canisters has been selected. The other actions performed to satisfy this specification are:

- Development of a labeling method. This includes performing studies of various labels and labeling methods to choose a reference process, selecting a lettering shape and style, fabricating test labels, and confirming the visibility of the labeling scheme even after frit blasting.

- Inclusion of the labeling method in the canister procurement specifications.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

- Estimation of the service life of the label.

Development of Labeling Method

The reference labeling technique was chosen based on tests of the visibility of labels applied by various techniques, both before and after decontamination of the canister by frit blasting (see Part 5, Item 400). The label made by the reference technique was best able to maintain its legibility after decontamination. Tests through an aged shielding window showed that the label could be viewed remotely up to 10 feet away without magnification, and could be easily read at least 30 feet away with a 10X magnification lens attached to a video camera. The label was most visible under indirect light which produced a profile shadow. Intense direct lighting tended to reduce the contrast between the label and the canister, making it more difficult to read. Given proper lighting, viewing angle was found to have little effect on label legibility.

Labeling Requirements in Canister Procurement Specification

The canister labeling method selected by the DWPF is to bead-weld characters (using Type 308L welding rod) on the canister surface. The type face is sans serif style Megaron Medium. Letters are to be 5 cm high and 3.8 cm between centers. The canister vendor may use any method to provide uniform characters, subject to prior approval by DWPF. The alphanumeric code for identifying the DWPF canistered waste forms is a six digit alphanumeric string consisting of the letter "S" followed by five numbers. A label is placed on the top head and cylinder of each canister at the locations shown in Figures 4.300.2 and 4.300.3. After completion of labeling, characters are to have a profile height of about 0.16 cm. The label will be inspected with the rest of the canister, and any imperfections which could trap contamination will be removed before acceptance of the canister. This is included in the canister procurement specifications for the DWPF canister, which will be referenced in the Volume 8 of the WQR.

Estimation of Service Life

The DWPF will estimate the service life of the DWPF canister labels to provide assurance that the labels will remain legible throughout the specified period. The welding rod used as the bead-welded label characters on the canister surface will be Type 308L austenitic stainless steel. This is the same material used to assemble the canister (see Part 4, Item 100). The service life of the label should be comparable to that of the welds which hold the canister together, because the label will be made from the same material as the canister fabrication welds and should experience the same thermal treatment during filling. The service life of the label will be estimated. It will be shown that for reasonable estimates of the time of shipment, the service life is not exceeded. Thus, after filling the canister, the DWPF should not need to take any special precautions to protect the canister label. During the Startup Test Program, the microstructures of the label and the canister welds will be characterized, and related to one another.

Since the conditions of storage at the repository are not known the DWPF will assume that these will be similar to storage conditions at SRS. The DWPF

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

expects that the canister and its associated labels will maintain functionality during storage in the DWPF's Glass Waste Storage Building (see Part 1, Item 300), and transport to the repository. This is based on the following:

- The canister will be at a higher temperature than the storage building. Thus, water will tend to vaporize away from the canister and condense on cooler surfaces, such as the metal guides lining each storage location.

- The Glass Waste Storage Building will force air across the surface of each canister at all times, keeping the surface dry.

- The flow of forced air will keep the temperature relatively low, thus limiting the rate of any corrosion reaction.

- The radiation dose rate will be relatively low. In conjunction with the small amount of water vapor present near the canister surface, this implies generation of nitric acid vapor should be negligible.

If the repository establishes controls similar to those above for lag storage prior to final packaging, the canister and its label will maintain its integrity through final packaging at the repository.

Documentation

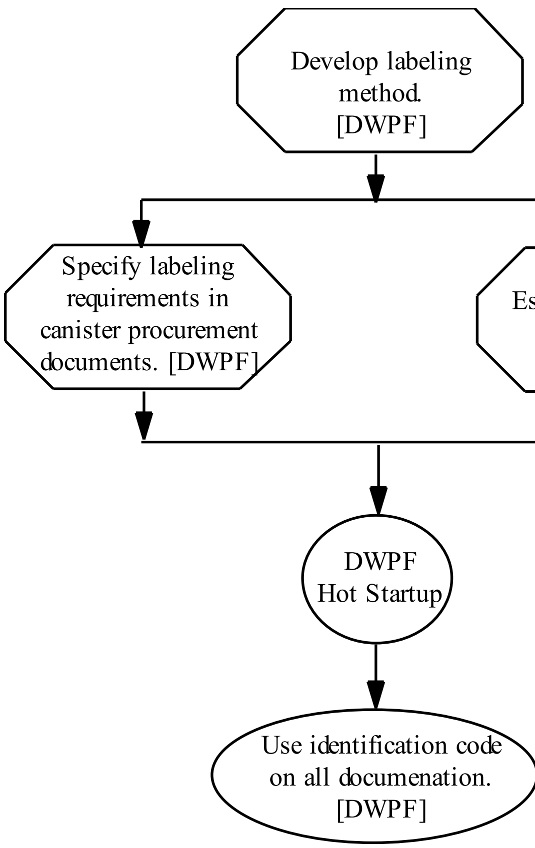
Volume 8 of the Waste Form Qualification Report will contain a description of the Glass Waste Storage Building, the controls to be applied to ensure label and canister integrity, and a report on the relationship between the label and the canister welds, which experience similar thermal histories.

Both the Production Records and the Storage and Shipping Records will identify particular canisters by the code on the label affixed to them. This code, unique to each canister, will be the key to tracing the records for each canister and canistered waste form. All of the records which support the information reported in the Production Records and the Storage and Shipping Records will be keyed to that code.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

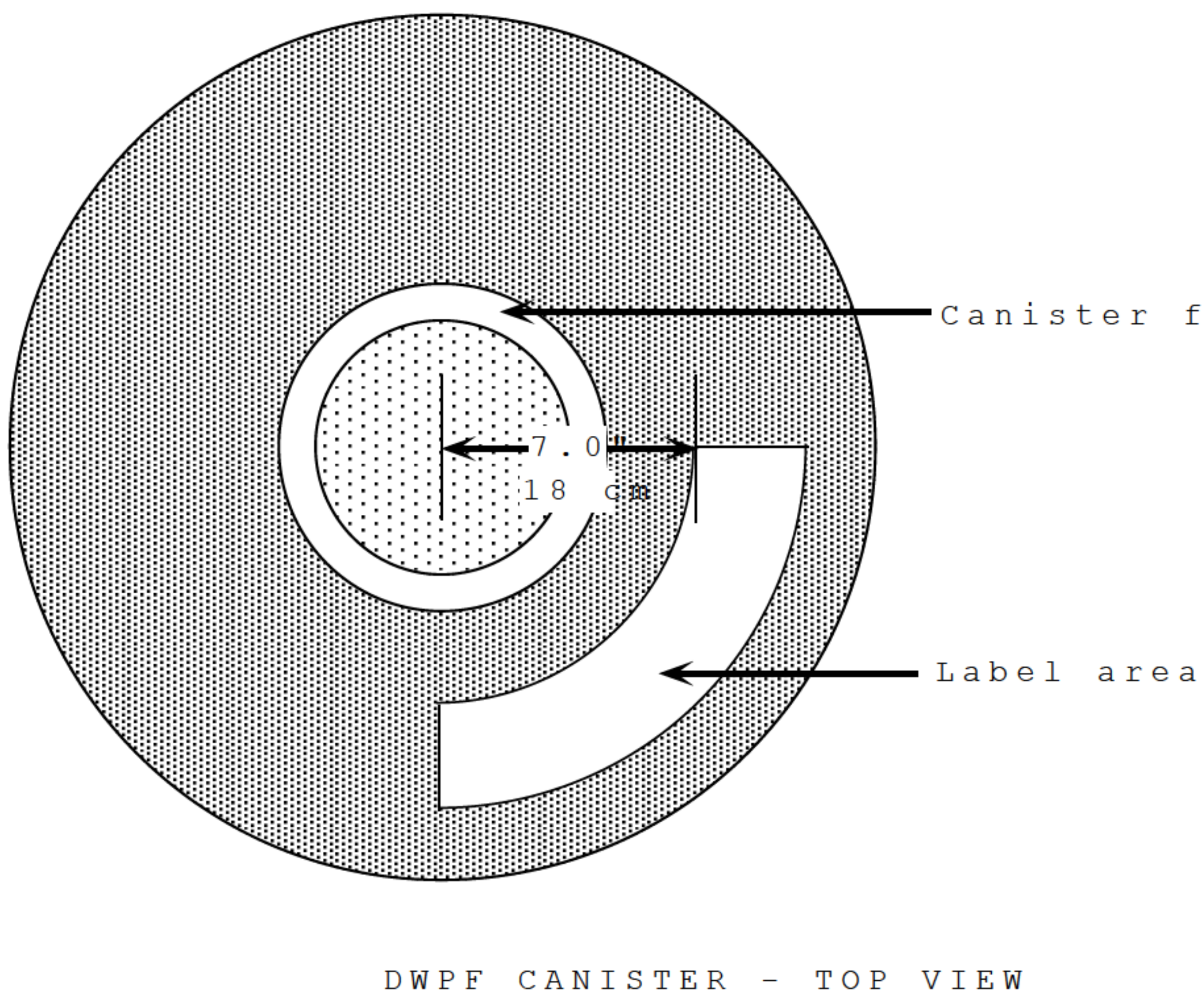
FIGURE 4.300.1 Tasks planned to satisfy Specification 2.3, Identification and Labeling Specifications.



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

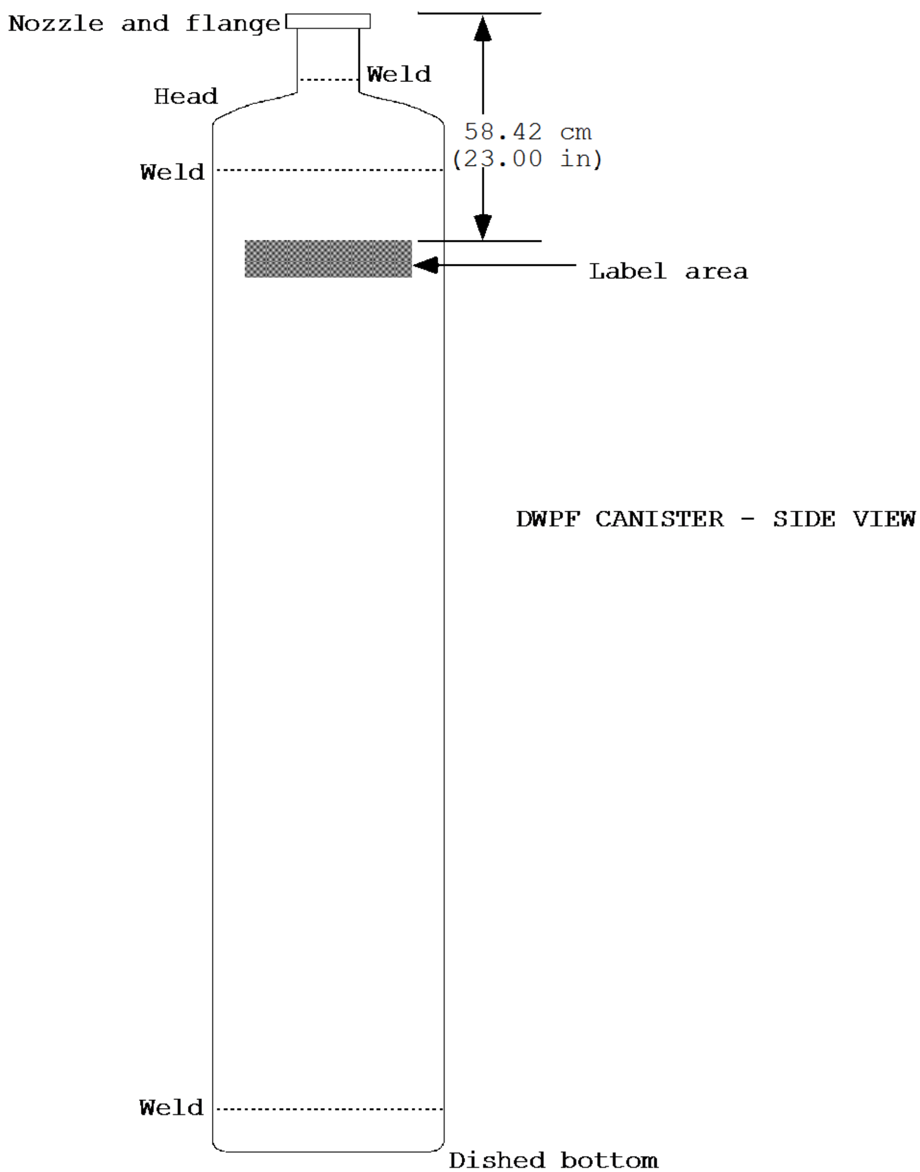
FIGURE 4.300.2 Placement of top label on DWPF canister.



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

FIGURE 4.300.3 Placement of side label on DWPF canister (nominal dimensions shown).



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

The Producer must describe in the WCP that the strategy for meeting these specifications will meet the requirements of the WA-SRD.

2.4.1 Length Specification

The overall length of the unfilled canister, after accounting for the closure method, shall be 3.000 m (+ 0.005 m, - 0.020 m), including the neck and handling flange. The measured length of the unfilled canister shall be reported in the Production Records.

2.4.2 Diameter Specification

The outer diameter of the unfilled canister shall be 61.0 cm (+ 1.5 cm, - 1.0 cm). The measured diameter of the unfilled canister shall be reported in the Production Records.

Compliance Strategy

The DWPF will ensure that the canister dimensions are within the specified limits by controlling the canister procurement process. This control will be accomplished through the canister procurement specifications which include inspections to ensure that the canister is acceptable before it leaves the vendor’s shop. The length and diameter of the unfilled canisters will be measured by the canister supplier prior to shipment to the DWPF. Measurements of non-radioactive canistered waste forms produced under conditions representing the range of those expected in the DWPF show that the vitrification process does not significantly affect the dimensions of the canistered waste form. Thus, the filled DWPF canisters (canistered waste forms) will also meet the dimensional requirements and the DWPF’s strategy for controlling dimensions is acceptable. The weld plug will extend approximately 0.002 m above the nominal 3 m of canister length.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 4.400.1. These are:

- Development of requirements for the canister length and diameter, which have been included in the canister procurement specifications. This also includes identification of canister inspection requirements to ensure that the specifications are met at the vendor's shop.

- Determination of the change in canister dimensions during glass pouring at the pilot plant facilities.

- Determination of the additional length due to the weld plug.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

Canister Procurement Specifications

The DWPF has developed detailed canister procurement specifications which specify the length and diameter of canisters. In addition, inspection requirements are being defined, to ensure that the purchased canisters actually meet specifications before they leave the vendor's shop.

Change in Dimension During Pouring

Seven prototypical DWPF canisters were carefully measured and then filled with glass at the SRS pilot plant facility under both design basis (continuous filling) and the most likely upset (pouring rapidly in short bursts) conditions. The data for these tests can be found in Volume 8 of the Waste Form Qualification Report. Seven canisters were used so that estimates of uncertainties for each condition could be developed (however, the two data sets proved to be indistinguishable in terms of this specification).

These canisters were then re-measured to determine the effects of canister filling on canister dimensions. Figure 4.400.2 contains a canister diagram indicating measurement locations, and the means and standard deviations of the measured dimensions. The diameter of the canisters was measured at five different elevations: top end, top, middle, bottom, bottom end. The reported diameter value, 24.00 ± 0.12 inches (60.96 ± 0.30 cm), was calculated using measurements from all of the canisters at all elevations. The diameter is well within the specification even after filling (maximum deformation: 0.161 inches (0.409 cm). Based on the small process-induced dimensional changes, it appears that compliance with the dimensional specifications can best be established through strict adherence to the canister procurement specifications. Volume 8 of the WQR will provide the technical basis for this conclusion, and the details of the measurements and calculations. The conclusions drawn from canisters filled at the SRS pilot facility will be confirmed during the DWPF Startup Test Program and these results also reported in Volume 8.

Canister Weld Plug Height

The final weld plug increases the overall length of the canistered waste form slightly. This is due to the fact that the weld plug protrudes above the top of the nozzle flange after upset resistance welding (see Part 4, Item 200). For the seven prototypically filled canisters used in the drop tests (see Part 5, Item 700), the values for this protrusion ranged from 0.032 to 0.038 inches (less than 0.001 m). The canister procurement specification limit on canister length is tighter than the WAPS requirement and thus this small increase in length due to the weld plug will not affect the DWPF's ability to comply with the WAPS. The increase in canister length due to the weld plug will be further evaluated during the weld parametric study (see Part 4, Item 200).

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

Documentation

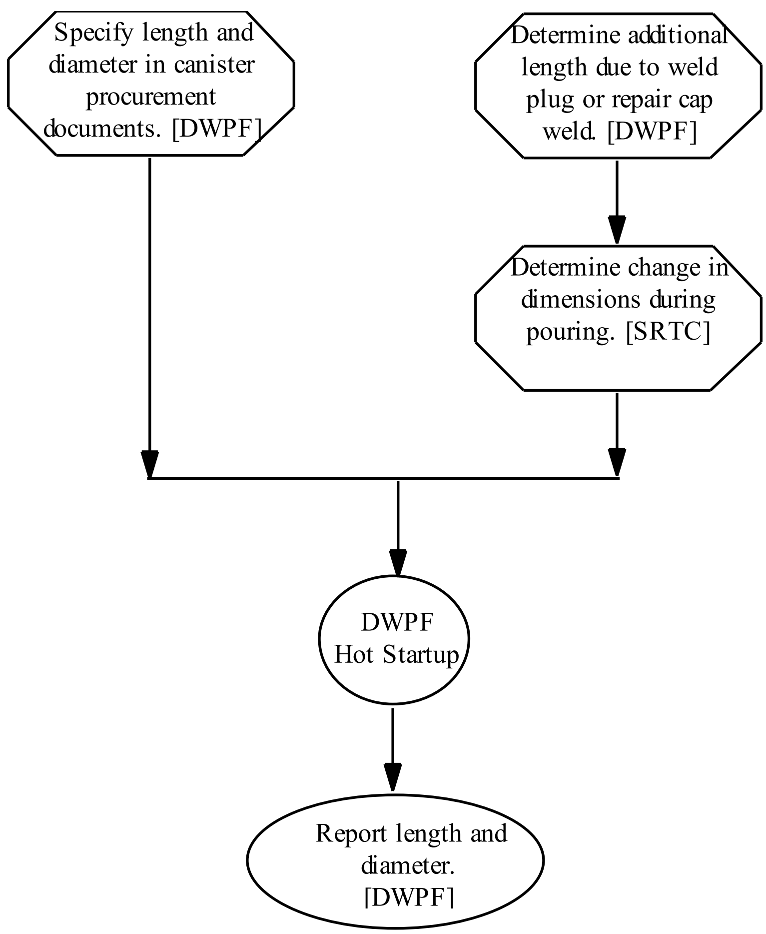
Volume 8 of the Waste Form Qualification Report (WQR) will reference the canister procurement specifications, and inspection procedures. The WQR will also include a report on the effect of the vitrification process on the canistered waste form dimensions, including the additional length due to the weld plug.

The Production Record for each canistered waste form shall contain the as-purchased diameter and length of the canister. If these values are outside the range for canister diameter and length, the canister will be identified as a nonconforming item. Its disposition will be in accordance with the procedure outlined in Part 6, Item 300.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

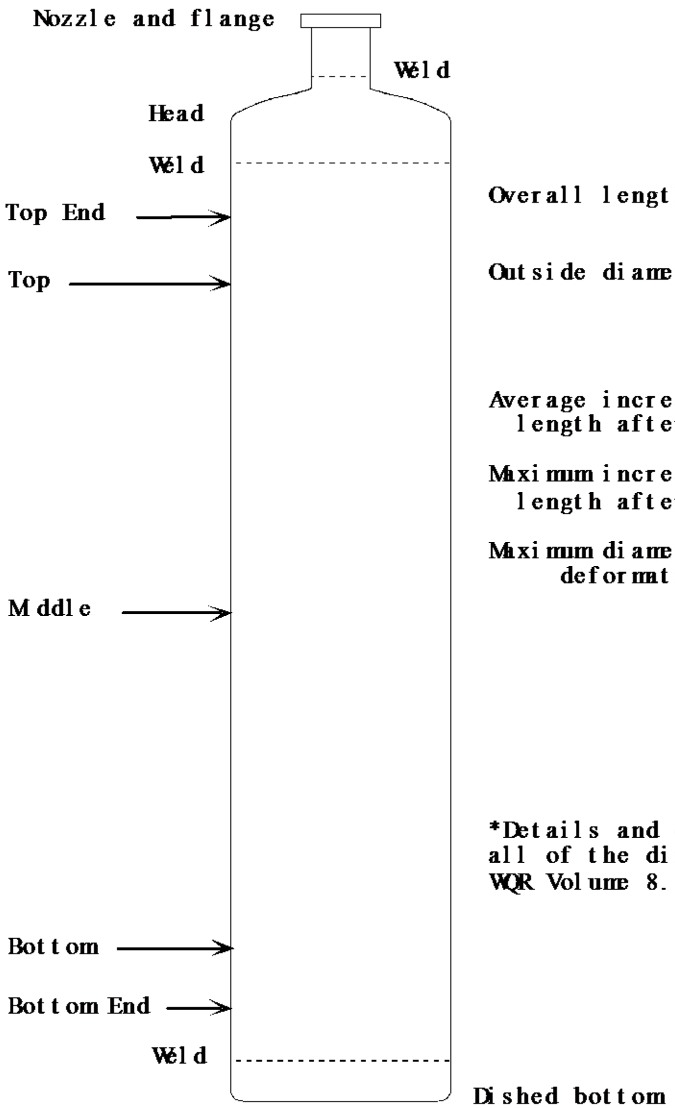
FIGURE 4.400.1 Tasks planned to satisfy Specification 2.4, Specification for Canister Length and Diameter.



PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.4 SPECIFICATION FOR CANISTER LENGTH AND DIAMETER

FIGURE 4.400.2 Components and dimensions of the seven DWPF canisters filled under design-basis and possible upset conditions in pilot plant tests (calculated for all canisters)*.



	$\overline{x}$	$\pm\sigma$
Overall length	117.97 in (299.64 cm)	0.06 in (0.15 cm)
Outside diameter	24.00 in (60.96 cm)	0.12 in (0.30 cm)

Average increase in length after filling	0.02 in (0.05 cm)
Maximum increase in length after filling	0.08 in (0.20 cm)
Maximum diametrical deformation	0.161 in (0.409 cm)

*Details and calculations concerning all of the dimensions can be found in WQR Volume 8.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

3.1 FREE LIQUID SPECIFICATION

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 the detection limits, in the WQR.

Compliance Strategy

The vitrification process, operating at 1150°C, with a nominal melter residence time of 65 hours, will evaporate all free liquids from the waste feed stream as the waste is converted into molten glass. The glass pouring into the canister will be at a temperature of about 1000°C, and the canister under a slight vacuum. Thus, free liquids will not enter the canister with the molten glass stream, and any liquids present in the canister prior to pouring are unlikely to remain due to the heat of the molten glass and the reduced pressure.

The most likely source of free liquids in the canister is the water/frit slurry used to decontaminate the canister. A shrink-fit seal has been developed to ensure that this slurry does not enter the canister.[1] This temporary seal called the Inner Canister Closure (ICC) will be inserted into the canister neck after filling, and before canister decontamination, to prevent inleakage of the decontamination slurry. Every ICC will be tested to ensure it is watertight. Administrative controls will be used to prevent the introduction of any free liquids into the canisters before or after glass filling. Tests will be performed in the facility to demonstrate the effectiveness of the controls.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.100.1. They are

- Identification of the sources of liquids in the canistered waste form.
- Demonstration that borosilicate glass does not contain free liquids, and that they cannot enter the canister with the molten glass stream.
- Development of controls to prevent the introduction of free liquids into the canister, either before or after filling.
- Development of a leaktight temporary seal to be used during canister decontamination.
- Demonstration of the effectiveness of the controls as part of the Startup Test Program.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

Identification of the Sources of Liquids

SRTC will conduct a review of the entire process to identify all of the possible sources of free liquids and other foreign materials in the canistered waste form. This review will begin at the canister vendor's shop and proceed through application of the final closure weld at the DWPF. These results will be documented in Volume 9 of the Waste Form Qualification Report (WQR).

It is assumed that water vapor will be present inside the canistered waste form from the ambient cell air. Worst case dew point calculations, based on a 185°C sealing temperature and the most humid credible atmospheric conditions (which produce a dew point temperature of 35°C due to waste heat loading), indicate a maximum of 4.6 grams of water vapor will be trapped in the vapor space within DWPF canistered waste forms. The somewhat elevated steady-state temperatures expected during interim storage at the DWPF will prevent this water vapor from condensing.

Absence of Free Liquids in DWPF Glass

As noted in the Compliance Strategy, the high temperatures of the DWPF vitrification process make it very unlikely that process liquids will survive to enter the canister with the pouring glass stream. In addition, borosilicate waste glass itself contains no free liquids. The WQR will document that borosilicate waste glass will contain no detectable free liquids, and that free liquids cannot enter the canister with the molten waste glass.

Development of Controls to Prevent Ingress of Free Liquids

Based on the identification of the sources of free liquids, the DWPF will establish controls to prevent the introduction of free liquids into the canister, both before and after filling. These will be primarily procedural (e.g., inspections) but will also include the temporary seal (described below) and final closure weld (described in Part 4, Item 200). These controls will be described in the WQR.

Development of Temporary Seal Process

After filling with glass, the canister is decontaminated by blasting a slurry of glass frit at the canister surface. This is the most likely method of ingress of free liquids. The DWPF has developed a watertight temporary seal to prevent water (or other liquids) from entering the canister after filling before the final closure weld is made. A shrink-fit seal technique was selected because it uses the heat from the glass filling operation to make the seal. It is a simple, reliable process because it requires no additional equipment in the hot cell.

The temporary shrink-fit seal, called the Inner Canister Closure (ICC), is made at the top of the canister nozzle after the canister has been filled with glass and vented to the off-gas system for to remove volatile species. Figure 5.100.2 outlines this process. The seal is made by placing the cold seal plug in the hot canister sleeve (emplaced in canister during fabrication – see Part

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

4, Item 200). As the hot sleeve and the plug equilibrate, the hot sleeve shrinks around the plug to form a watertight seal (see Figure 5.100.3).

Both the sleeve and the ICC plug are purchased to specifications in the canister procurement document. The joint between the shrink fitted sleeve and the nozzle of the canister is tested for leaktightness as a part of acceptance testing of the fabricated canister. The joint must have a leak rate of $< 1 \times 10^{-4}$ atm-cc/sec helium for acceptance. This testing ensures that the leak test performed after insertion of the ICC is actually a test of the seal and not of the sleeve's tightness.

After the canister cools the ICC (temporary seal) and sleeve to neck joint are tested for water tightness. This is done using a pressure-decay leakage detector, which has been experimentally demonstrated to be sensitive to leaks $\geq 1 \times 10^{-5}$ atm-cc/sec helium. A leak rate of $\leq 2 \times 10^{-4}$ atm-cc/sec helium has been experimentally established[1] as the rate at which no water would enter the canister during decontamination. All ICCs will be tested before the canister is allowed to transfer to the Canister Decontamination Cell (see Part 3, Item 600). Each ICC must have a leak rate of $\leq 2 \times 10^{-4}$ atm-cc/sec helium (indicating a watertight seal) for acceptance.

If the ICC is not water tight, it will be re-worked before transfer of the canister is allowed. In the re-work process, the flange is heated rapidly so that it expands away from the sleeve and plug. They then fall inside the canister. Oversized cylindrical repair plugs are then shrink-fit in the nozzle to replace the original seal. After re-work, the ICCs are then retested. If an acceptable leak rate cannot be achieved for any canister, even after re-work, the glass-filled canister will be treated as a nonconforming item and dispositioned according to Part 6, Item 300.

If the canister is too cool to form an inner canister closure on the pour turntable it will usually be removed uncovered to the inner canister closure station. Placing a cover on and removing it from the canister will be at least as likely to introduce foreign materials into the canister as simply picking the canister up and moving it. In addition, the current DWPF grapple cannot pick up the canister with a cover on it. However, if a canister must be moved to the storage racks (an unusual occurrence), a cover will be placed on the canister while it is in the storage racks waiting for the installation of an ICC. The final canister closure weld will then prevent prohibited materials from entering the canister during transport and storage (see Part 4, Item 200).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

Demonstration of Effectiveness of Controls

As part of the Startup Test Program (see Appendix 1.200.3), several filled canisters will be tested for the presence of liquids, and other foreign materials. The purpose of the examination is to demonstrate the effectiveness of the controls established by the DWPF. A hygrometer will be used to measure the dewpoint and relative humidity inside the canister free volume space. The results of this testing along with the detection limits will be presented in the WQR.

Documentation

Volume 9 of the Waste Form Qualification Report (WQR) will document that free liquids will not enter the canister with the stream of molten glass, and that there are no free liquids in borosilicate waste glass. This will include the results of testing of glass heated to temperatures up to 500°C to show that no free liquids are generated as well as other experimental evidence of the absence of liquids in borosilicate waste glass. These results will also include the detection limits of the instruments used for testing.

The WQR will also include a report on the controls used to keep free liquids out of the canistered waste form, including data from non-radioactive testing on the leak rate of the temporary canister closure. This testing will validate the previous results which showed that acceptable leak rates (of $\leq 2 \times 10^{-4}$ atm-cc/sec helium) would prevent the entrance of water into the canister. The results of testing canisters filled under simulated production conditions will also be reported.

The Production Record for each canistered waste form will include the results of the leak test of the temporary canister closure in the canistered waste form prior to decontamination.

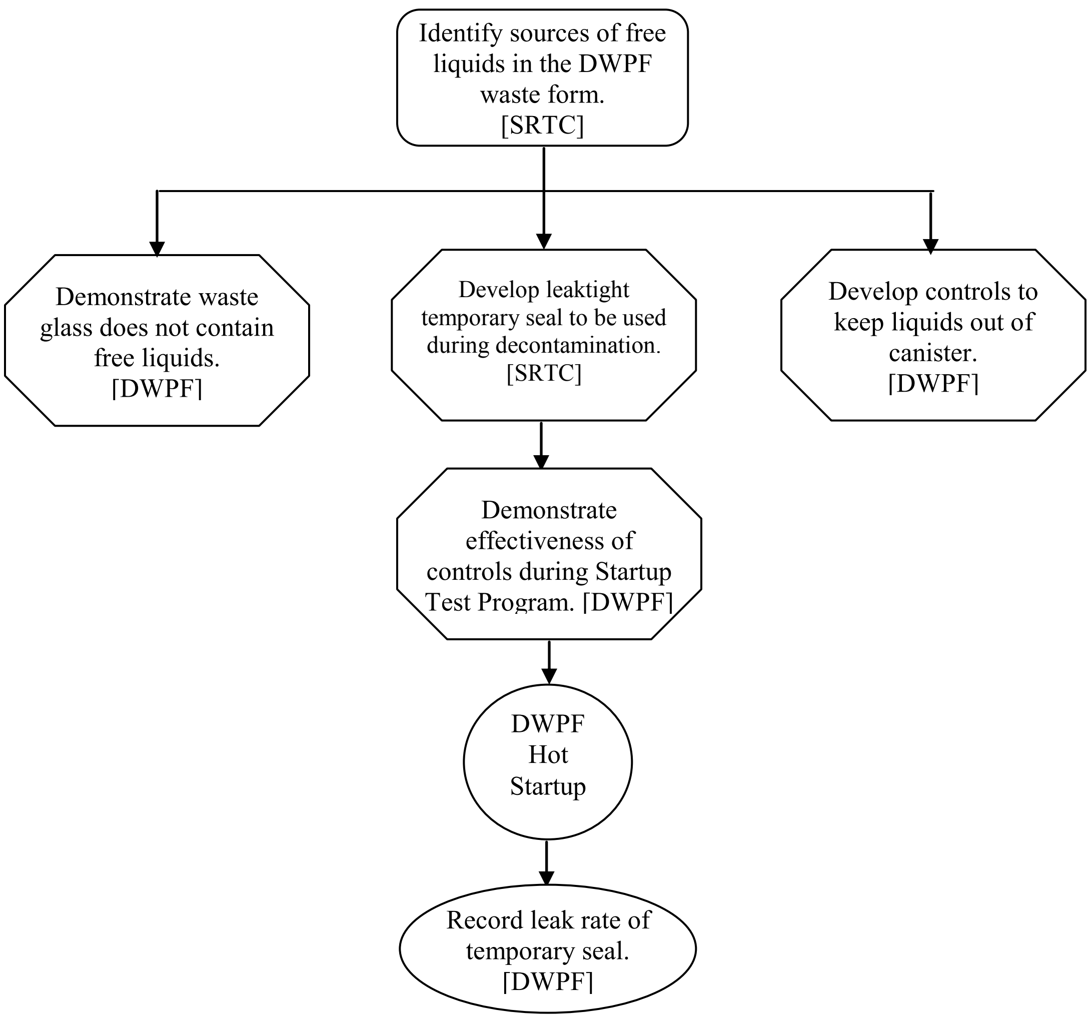
References

1. J. W. Kelker, **Development of the DWPF Canister Temporary Shrink-Fit Seal**, USDOE Report DP-1720, E. I. Du Pont de Nemours, Inc., Savannah River Laboratory, Aiken, SC (1986).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

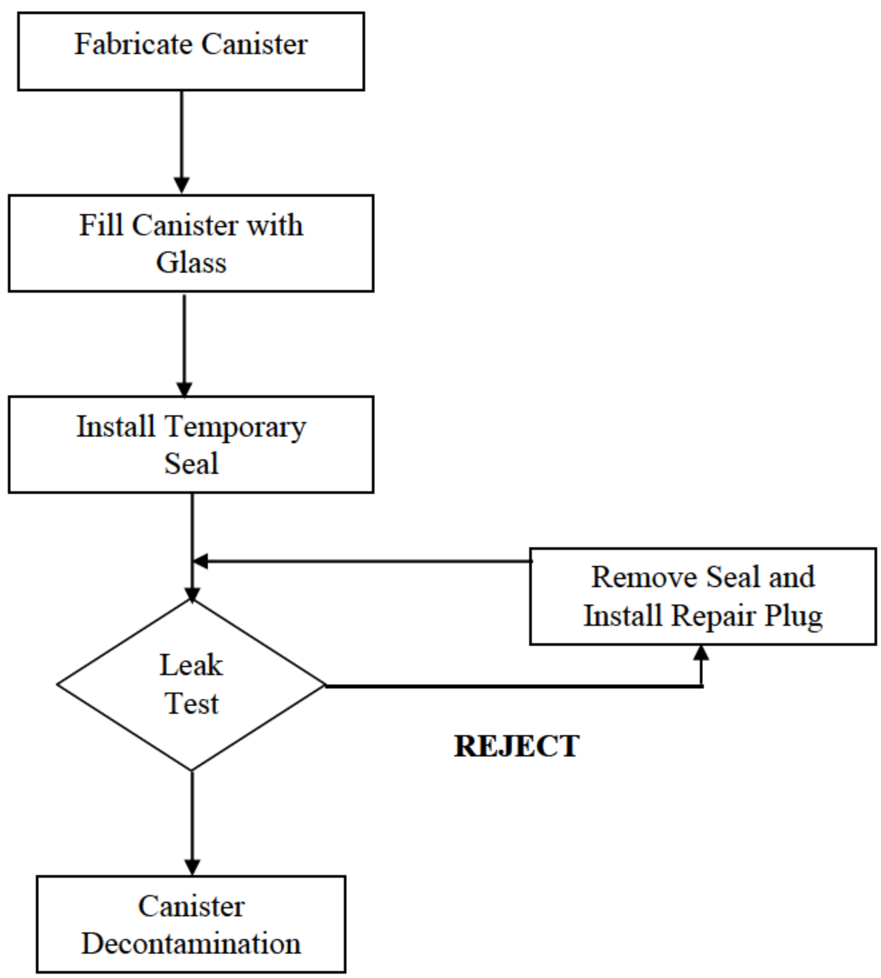
FIGURE 5.100.1 Tasks planned to satisfy Specification 3.1, Free Liquid Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

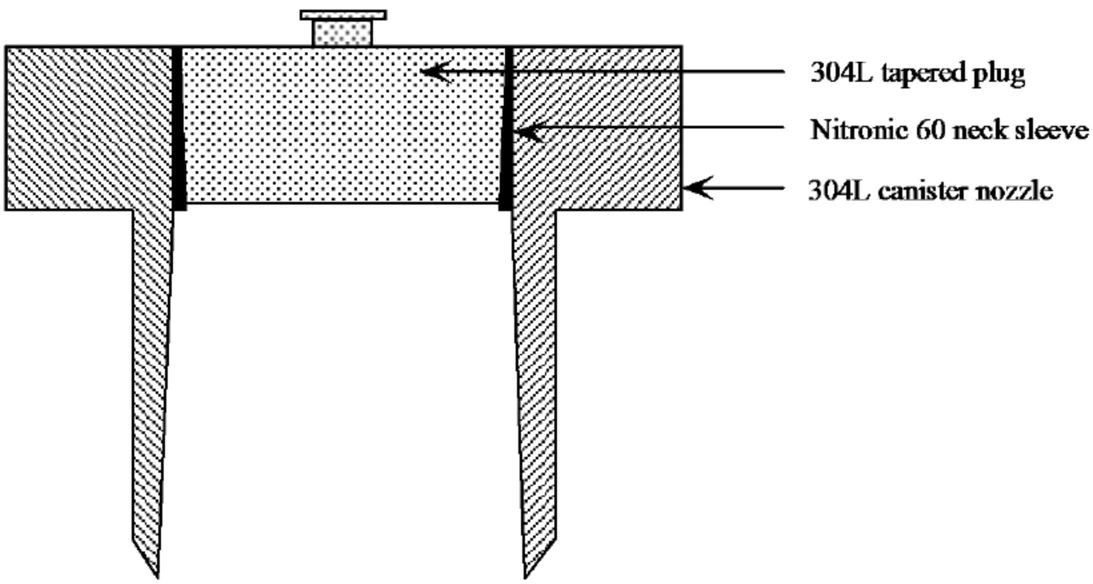
FIGURE 5.100.2 Inner Canister Closure (temporary seal) process.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

FIGURE 5.100.3 Completed Inner Canister Closure (temporary shrink-fit seal).



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

3.2 GAS SPECIFICATION

The Producer shall ensure that the canistered waste form does not contain detectable amounts of free gas other than air, the residuals of air, inert cover, 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 the 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 in the event that the canistered waste form temperature exceeds 400°C. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C.

Compliance Strategy

The DWPF will exclude free gases (other than air, the residuals of air, inert cover and radiogenic gases) from the canistered waste form through a combination of physical and administrative control measures. Administrative controls will be used to prevent the introduction of any gases into the canisters after filling and sealing. Physical barriers will be used to prevent the ingress of extraneous (non-radiogenic) gases. The amounts of gases generated due to radioactive decay will be calculated.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.150.1. These are:

- Identification of the sources of free gas.

- Demonstration that borosilicate glass does not contain free gas, and that it cannot enter the canister with the molten glass stream.

- Demonstration that exposure of the glass to 500°C will not release free gas. The limit of 500°C is conservative since the limit for canister exposure after cooldown is 400°C (see Part 3, Item 600).

- Calculation of the amount of gas generated radiogenically.

- Development and demonstration of controls to ensure that free gases are not introduced into the canister.

During processing, there is no process step which can pressurize the DWPF canistered waste form. Thus, the ability to meet the internal pressure specification need only be confirmed during the Startup Test Program.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

Identification of Sources of Free Gas

The canister is filled with glass, and the inner canister closure (ICC) is emplaced, in the air atmosphere in the DWPF melt cell. No cover gas is used for welding. The only sources of gas are the waste glass itself, the ambient cell atmosphere, and the helium used in leak testing of the ICC.

Absence of Free Gas in DWPF Glass

Borosilicate waste glass itself contains no free gas, due to the nature of the vitrification process. Volume 9 of the Waste Form Qualification Report (WQR) will document that borosilicate waste glass will contain no free gas, and that free gas cannot enter the canister with the molten waste glass.

Effects of Exposure to Temperature of 500°C

The gases that might be generated at temperatures up to 500°C will be determined from both the technical literature, and new experimental evidence. All available evidence indicates that the canistered waste form does not contain free gas. DWPF glass may release small amounts of volatile materials upon exposure to 500°C, which will re-condense when the canistered waste form cools. The composition and amounts of such materials will be reported in response to Specification 3.5 (Part 5, Item 300).

Radiogenic Gas Generation

During long-term storage the canistered waste form will be continuously irradiated by beta-gamma emissions from fission products and by alpha emissions from transuranic nuclides. Calculations[1] indicate that approximately 2×10^5 years of storage are required to produce enough helium to increase the gas pressure to 7 psig. Any helium that enters the canister during leak testing would not contribute substantially to this amount. These results will be documented in the WQR.

Controls to Exclude Free Gas

Administrative controls will be used to prevent prohibited gases from entering the canister prior to sealing. The leaktight temporary seal described in Part 5, Item 100, and the final closure weld described in Part 4, Item 200, will prevent gases from entering the canister after closure. As indicated in Part 5, Item 100, during the Startup Test Program, several filled canisters will be tested for the presence of free gas, and other foreign materials. The purpose of the examination is to demonstrate the effectiveness of the controls established by the DWPF.

Documentation

Volume 9 of the Waste Form Qualification Report (WQR) will include a report on the absence of free gas in borosilicate waste glass, gas generation due to exposure to the glass transition temperature, and gas generation due to radioactive decay. The WQR will include the detection limit of the instruments used for testing. The WQR will also include a report on the

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

controls to be used to prevent introduction of other gases into the canistered waste form.

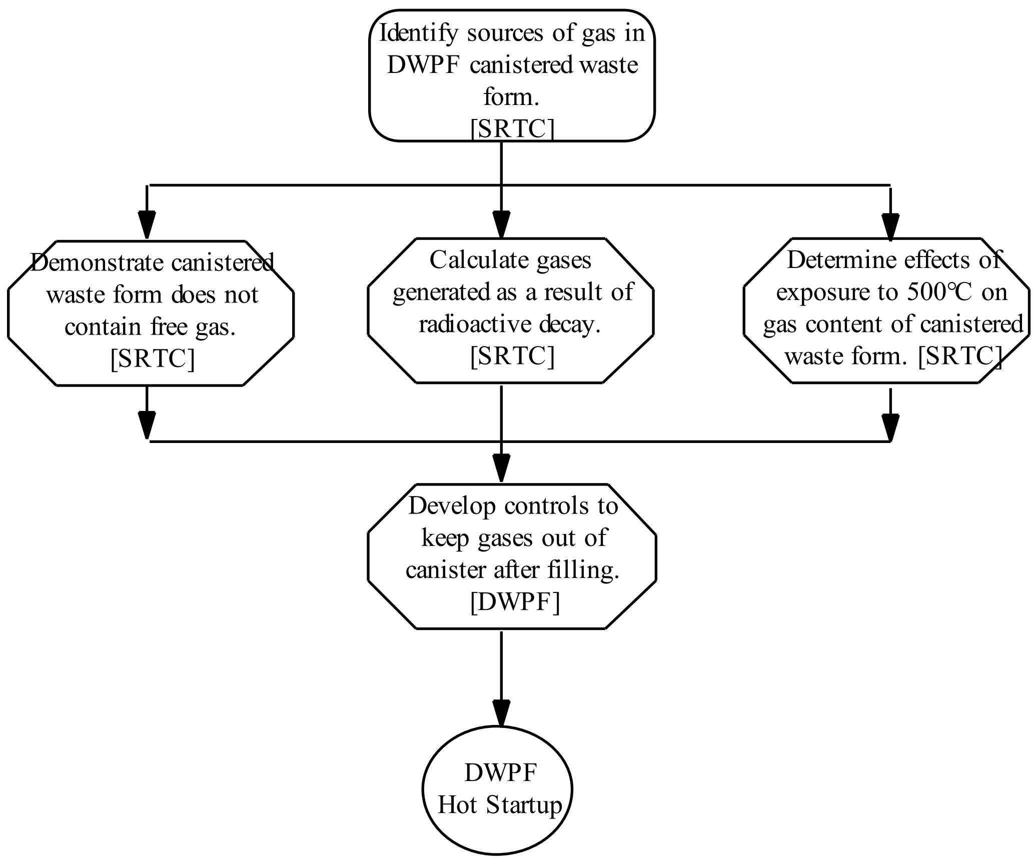
References

1. R. G. Baxter, **Description of Defense Waste Processing Facility Reference Waste Form and Canister**, USDOE Report DP-1606, Revision 2, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC (1988).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

FIGURE 5.150.1 Tasks planned to satisfy Specification 3.2, Free Gas Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

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 in the event that the temperature exceeds 400°C. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C.

Compliance Strategy

The DWPF will prevent the presence of explosive, pyrophoric, or combustible materials in the canistered waste form through a combination of physical and administrative control measures. These include procedures to control procurement, the nature of the vitrification process, and physical barriers to prevent the ingress of prohibited materials into the DWPF canister. The DWPF will demonstrate that waste glass remains free of explosive, pyrophoric, or combustible materials, even if exposed to temperatures up to 500°C.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.200.1. They are

- Identification of the sources of explosive, pyrophoric, or combustible materials.

- Demonstration of the absence of explosive, pyrophoric, or combustible materials in borosilicate waste glass.

- Demonstration that exposure of the waste glass to temperatures up to 500°C does not lead to the formation of explosive, pyrophoric, or combustible materials.

- Development of controls to prevent the introduction of explosive, pyrophoric, or combustible materials.

Sources of Explosive, Pyrophoric, or Combustible Materials

SRTC will conduct a review of the entire process to identify any possible sources of explosive, pyrophoric, or combustible materials, and other foreign materials, in the canistered waste form. This review will begin at the canister vendor's shop, and proceed through application of the final closure weld at the DWPF.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

Absence of Explosives, Pyrophorics, or Combustibles in Glass

Borosilicate waste glass does not contain explosive, pyrophoric, or combustible materials because all components of the glass have already been oxidized at high temperatures. The presence of glass in the canister is sufficient evidence of the exposure of the glass to high temperatures, because glass can only be poured into a canister while molten. In tests with simulated waste glass, it was not possible to pour waste glass at temperatures below 900°C from a melter similar to the DWPF melter.

Effects of Exposure of Glass to Temperature of 500°C

Because the waste glass in a filled canister has already been subjected to temperatures much greater than 500°C, any further exposure of the glass to that temperature does not cause observable changes. In tests performed at SRTC, and at the University of Florida, exposure of simulated waste glasses similar in composition to the DWPF glass to temperatures somewhat greater than 500°C for several days caused no changes in the phase makeup of the glass, indicating that no new (possibly explosive, pyrophoric, or combustible) phases had formed.[1-4]

Controls to Bar Explosives, Pyrophoric, and Combustible Materials

The DWPF is also developing controls to keep explosives, pyrophorics, and combustibles out of the canister before and after filling. The specifications for canister procurement require that the canister manufacturer clean and degrease the canister, and cover the nozzle opening with a metal cap for shipment. This will prevent the introduction of such materials in the empty canister. Each canister will be inspected by DWPF personnel before it is introduced into the Vitrification Building to ensure that there are no visible prohibited materials in the canister. After filling with glass, the temporary canister closure will prevent unwanted materials from entering the canister between the time the canister is filled and the time the final canister closure weld is made (see Part 5, Item 100). If the canister is too cool to form an inner canister closure on the pour turntable, it will be moved uncovered to the Inner Canister Closure Station. Placing a cover on and removing it from the canister will be at least as likely to introduce foreign materials into the canister as simply picking the canister up and moving it. In addition, the current DWPF grapple cannot pick up the canister with a cover on it. However, if a canister must be moved to the storage racks (an unusual occurrence), a cover will be placed on the canister while it is in the storage racks waiting for the installation of an ICC. The final canister closure weld will then prevent prohibited materials from entering the canister during transport and storage (see Part 4, Item 200).

Documentation

Volume 9 of the Waste Form Qualification Report will include a report on the absence of explosives, pyrophorics, and combustibles in borosilicate waste glass. The detection limits of the instruments used for testing will also be included. Volume 9 will also include a report on the controls used to keep

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

explosives, pyrophorics, and combustibles out of the canistered waste form, and on the effects of exposure of the glass to temperatures up to 500°C.

References

1. C. M. Jantzen, D. F. Bickford, D. G. Karraker and G. C. Wicks, "Time-temperature-transformation kinetics in SRL waste glass, "**Advances in Ceramics – Nuclear Waste Management**, 8, W. A. Ross and G. G. Wicks (eds.), 30-38 (1984).

2. D. F. Bickford and C. M. Jantzen, "Devitrification Behavior of SRL Defense Waste Glass," **Scientific Basis for Nuclear Waste Management, VII**, G. L. McVay (ed.), Elsevier, NY, 557-66, (1984).

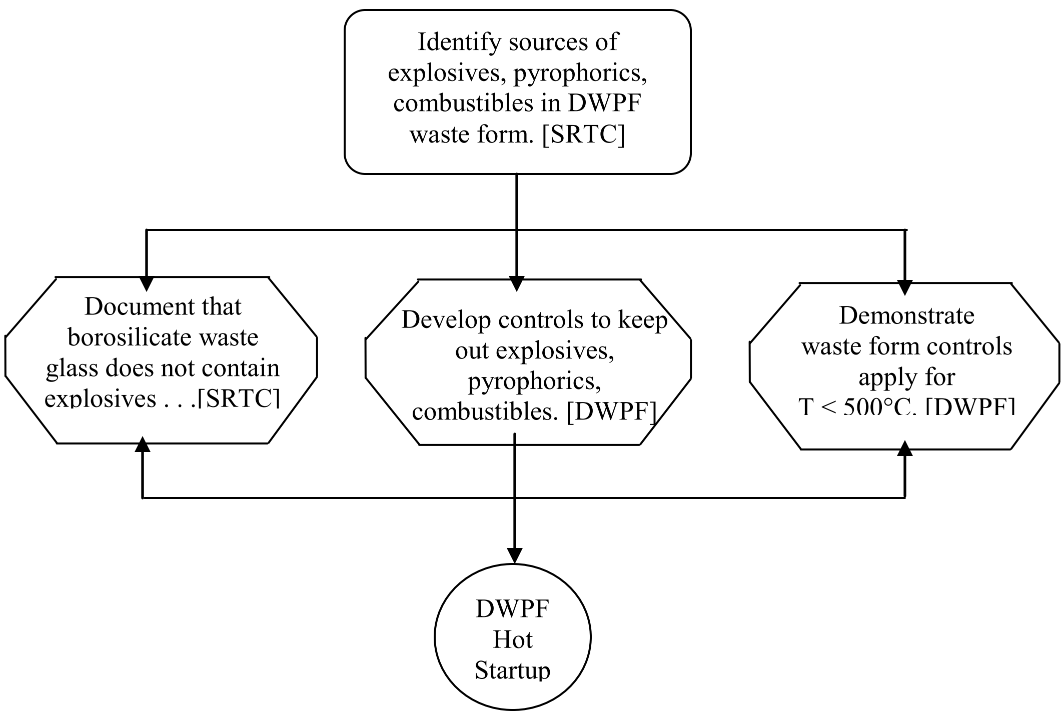
3. D. F. Bickford and C. M. Jantzen, "Devitrification of Defense Nuclear Waste Glasses: Role of Melt Insolubles," **J. Non-Cryst. Solids, 84**, 299-307 (1986).

4. D. B. Spilman, L. L. Hench and D. E. Clark, "Devitrification and Subsequent Effects on the Leach Behavior of a Simulated Borosilicate Nuclear Waste Glass," **Nuclear and Chemical Waste Management, 6**, 107-19 (1986).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

FIGURE 5.200.1 Tasks planned to satisfy Specification 3.3, Specification for Explosiveness, Pyrophoricity, and Combustibility.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.4 ORGANIC MATERIALS SPECIFICATION

3.4 ORGANIC MATERIALS SPECIFICATION

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

Compliance Strategy

It is important to prevent organic materials from entering the canister, because they could potentially mobilize the radionuclides by the formation of complexes or by generation of radiolytic gases. Borosilicate waste glass is an inorganic material and, thus, introduces no organic materials into the canister. The canisters themselves will be degreased by the manufacturer, using materials specified in the canister purchase specification, prior to receipt at SRS. The vitrification process, operating at about 1150°C, will volatilize the organics that are present in the waste feed stream, such as the phenyl groups from the tetraphenylborate salt and formic acid (see Part 2, Item 100). Administrative controls will be used to prevent the introduction of organics into the canisters both before and after filling the canister with glass.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.250.1. They are

- Identification of possible sources of organic materials.
- Development of controls to prevent the introduction of organic materials.
- Demonstration of the effectiveness of the controls during the Startup Test Program.

Sources of Organic Materials

SRTC will conduct a review of the entire process to identify all possible sources of free liquids, and other foreign materials, in the canistered waste form. This review will begin at the canister vendor's shop, and proceed through application of the final closure weld at the DWPF.

Temperatures of 575°C and 775°C are used to decompose organic molecules in the standard tests ASTM D482-801 and ASTM E830-812 (tests used to assess the amount of ash from organic materials). The DWPF waste glass will be vitrified at 1150°C. Organics present in the waste feed streams will be volatilized and become part of the melter off-gas system; they will not be incorporated into the waste glass. Organics present in the canister prior to filling will volatize when the molten glass is poured into the canister. Organics which could enter the canister after glass filling are therefore of primary concern in establishing compliance with this specification.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.4 ORGANIC MATERIALS SPECIFICATION

Controls to Prevent Introduction of Organic Materials

There are two main types of organic materials which could be present in the canistered waste form: greases from canister fabrication and hydraulic fluid from the welding press. Controls are being developed to prevent the introduction of these, and any other, organic materials into the canistered waste form.

- Canister degreasing agents.

Each component of the canisters is degreased by the manufacturer prior to final assembly. This is currently specified in the canister procurement specification, which will be referenced in Volume 8 of the Waste Form Qualification Report.

- Hydraulic fluid from the canister welding process.

During press down of the temporary seal, it is possible that hydraulic fluid from the press could drip into the canister. However, the press is equipped with a drip pan designed to ensure that any dripped fluid will not enter the canister; also, the hydraulic fluid is a bright red color that is easily detected on the canister surface. The performance of the drip pan design will be reviewed, and, if necessary the drip pan will be redesigned to ensure its effectiveness.

Demonstration of Effectiveness of Controls

As part of the Startup Test Program (see Appendix 1.200.3), several filled canisters will be tested for the presence of organic materials. The purpose of the examination is to demonstrate the effectiveness of the controls established by the DWPF. The results of these tests will be reported in Volume 9 of the Waste Form Qualification Report (WQR).

Documentation

The WQR will identify the possible sources of organics in the canistered waste form, and the controls used to exclude each from the canistered waste form. The amount of organic material found in simulated canistered waste forms produced as part of the Startup Test Program will also be reported, as well as the detection limits of the instruments used for testing.

References

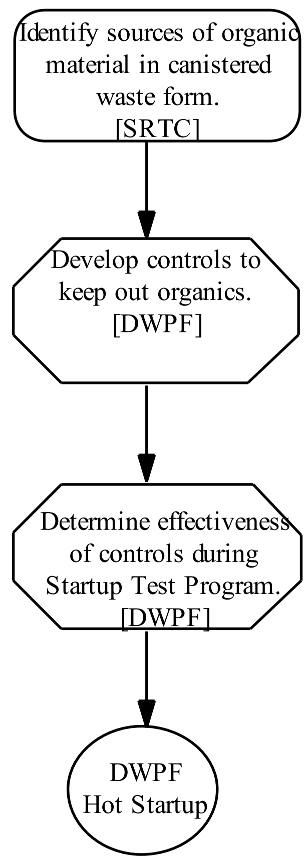
1. ASTM D482-80, Test Method for Ash from Petroleum Products.

2. ASTM E830-81, Test Method for Ash and the Analysis Samples of Refuse Derived Fuel.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.4 ORGANIC MATERIALS SPECIFICATION

FIGURE 5.250.1 Tasks planned to satisfy Specification 3.4, Organic Materials Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 CHEMICAL COMPATIBILITY SPECIFICATION

3.5 CHEMICAL COMPATIBILITY SPECIFICATION

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 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 in the event that the temperature exceeds 400°C, shall be discussed in the WQR. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C.

Compliance Strategy

The extent of chemical reactivity among the borosilicate waste glass, the canister, the gas in the void space, and the volatiles from the waste glass will be determined from either available technical literature or new experimental evidence, as necessary. Long-term testing indicates that the canistered waste form will not experience significant internal corrosion of the canister, as long as liquid water is excluded. Controls are being implemented to prevent liquid water from entering the canistered waste form, as described in Part 5, Item 100.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.300.1. These include:

- Identification of all of the materials expected to be present within the canistered waste form.

- Review of the literature as to the extent of reactions between the contents of the canister and the canister itself. Preliminary indications are that exclusion of liquid water from the canistered waste form will be necessary to avoid internal corrosion. The effects of chemical reactions on normal canister handling and abnormal occurrences will be identified and evaluated.

- Development of controls to exclude liquid water from the canistered waste forms, as described in Part 5, Item 100.

- If required by the literature review, an experimental evaluation of the extent of reactions between the contents of the canister and the canister itself.

- Determination of the effects of exposure of the canistered waste form to temperatures up to 500°C, on the compatibility of the canister and its contents.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 CHEMICAL COMPATIBILITY SPECIFICATION

Materials Present in the Canistered Waste Form

Borosilicate waste glass will not be the only material inside canistered waste forms from the DWPF. In particular, salts (primarily borates, halides, and sulfates) will volatilize from the stream of molten glass as it pours into the canister, and condense on the cooler canister wall. Experiments will be performed to identify all materials, besides waste glass, which will be present in the canistered waste form. These experiments will include examination of prototypic canisters filled under simulated production conditions and during the Startup Test Program, and sampling and analysis of any non-vitreous materials found.

Corrosion Reactions between the Canister and its Contents

The available literature is being reviewed to determine what is already known concerning the chemical reactivity of the borosilicate waste glass, any void space gases, and waste glass volatiles, with the stainless steel canister. This information will be supplemented with new experimental evidence to further investigate the chemical compatibility of the canister and its contents and include in Volume 9 of the Waste Form Qualification Report (WQR).

Studies investigating the effects of the internal canister environment on canister corrosion have concluded that no significant corrosion of the DWPF canister will occur during interim storage provided liquid water is prevented from entering the canister. Dew point calculations supported by dew point measurements show that even in the most humid conditions expected during canister sealing, vapor phase water will not condense inside the canister as it cools. The most humid credible conditions will produce a dew point of 31°C; however, a reference DWPF canister will maintain a surface temperature of 35°C due to waste heat loading, preventing condensation of the small amount of trapped water vapor.

Existing experimental information indicates that, as long as water has been excluded from the canistered waste form, DWPF processing will not significantly affect the ability of the 304L stainless steel canister to act as a container for the waste glass during interim storage at SRS, during transport to the repository, or during the retrievability period.[1]

Tests have been performed in which sensitized 304L coupons were exposed to molten glass for durations of up to 10,000 hours. Figure 5.300.2 shows the test design. After testing, the metal specimens were mounted in resin, ground and polished, and examined microscopically. The depth of intergranular penetration was determined, as well as the amount of material loss. It was concluded that the glass did not significantly interact with the 304L. Material penetration and loss rates were less than 3% of the maximum permissible rates (the maximum permissible rates are based on canister integrity during interim storage at SRS and the retrievability period at a repository (the combined total of which is assumed to be 100 years). The results of these tests will be included in Volume 9 of the WQR.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 CHEMICAL COMPATIBILITY SPECIFICATION

Stress corrosion of the canister material during transportation and handling will not be a hazard, as long as a halide/liquid mixture does not contact the canister surface (a very unlikely scenario).

If the literature review is inconclusive, an experimental program will be undertaken to better establish the extent of reaction between the canister and its contents. The nature of this program, if needed, will be based on the results of the review.

In addition, the effects of chemical reactions on normal handling and abnormal occurrences will be discussed in the WQR Volume 9.

Development of Controls to Exclude Liquid Water

In order to prevent internal canister corrosion, it is necessary to exclude liquid water from the canistered waste form. Administrative controls and canister closure techniques will be used to prevent the introduction of liquid water into the canistered waste form, as described in Part 5, Item 100.

Effects of Exposure to Temperature of 500°C

Simulated canistered waste forms (nonradioactive samples containing all materials expected to be present in actual DWPF products - including water vapor) will be exposed to temperatures up to 500°C. After the canistered waste form is exposed to 500°C, any corrosion or reaction products will be identified, and the extent of any reactions quantified.

Documentation

Volume 9 of the Waste Form Qualification Report will include a report on the extent of corrosiveness and chemical reactivity among the borosilicate waste glass, the canister, and any other materials which may be present within the sealed canister. Volume 9 will also include a report on the controls to be used to keep liquid water out of the canistered waste form.

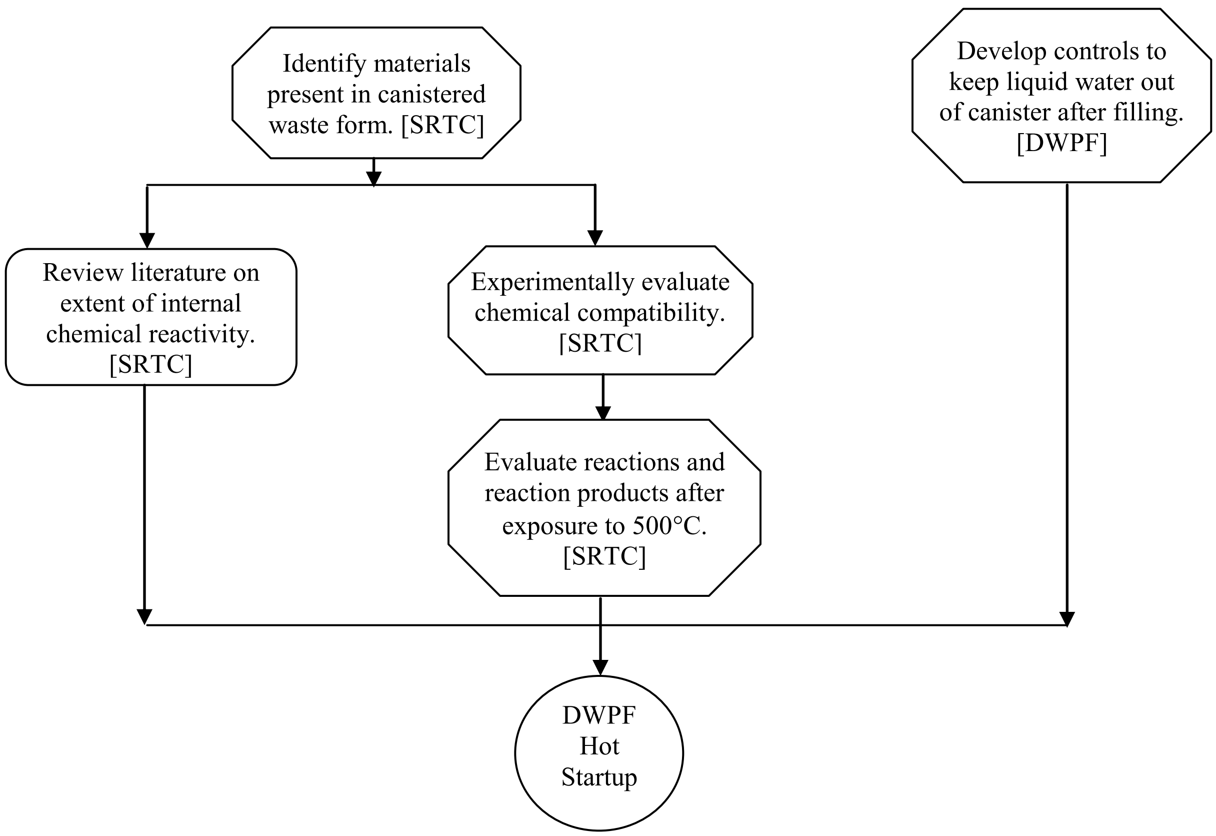
References

1. W. N. Rankin, **Compatibility Testing of Vitrified Waste Forms**, USDOE Report DP-MS-77-115, E. I. Du Point de Nemours & Company, Inc., Savannah River Laboratory, Aiken, SC (1978).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 CHEMICAL COMPATIBILITY SPECIFICATION

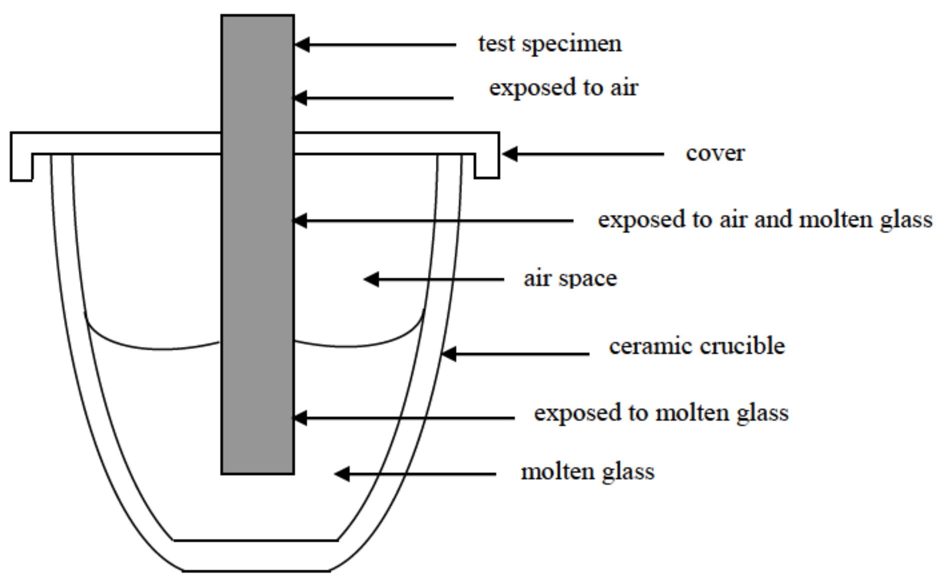
FIGURE 5.300.1 Tasks planned to satisfy Specification 3.5, Chemical Compatibility Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 CHEMICAL COMPATIBILITY SPECIFICATION

FIGURE 5.300.2 Experimental design of long-term corrosion tests.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.6 FILL HEIGHT SPECIFICATION

3.6 Fill Height Specification

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. Documentation supporting the selected method of compliance shall be provided in the WQR.

Compliance Strategy

The DWPF canister has a total internal volume of 26.0 ft^3 (735 L). The fill height corresponding to 80% of the volume of the empty canister is approximately 86 in (218 cm). The DWPF will comply with the specification by typically filling canisters with approximately 23.4 ft^3 or 175 gal of glass (660 L) to a fill height of 96 in (244 cm). This corresponds to about 90% of the available canister volume. The DWPF will use independent means for monitoring glass fill height. Infrared level detection is the technique to be used to ensure that the glass fill level reaches at least 86 inches.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.350.1. They are

- Development of method(s) to control glass level in the canister.

- Demonstration of the infrared level detection system during the non-radioactive portion of the Startup Test Program (i.e., Qualification Runs).

Glass Level Control Method

Infrared level detection will be used to monitor glass level and to ensure that a fill height of at least 86 inches (218 cm) is reached during the canister filling operation in the DWPF melt cell. Neutron transmission and gamma emission were the initial methods developed for glass level monitoring. However, during initial testing these methods for monitoring glass level were determined to be unsatisfactory.

Infrared Level Detection

Infrared level detection will be used on the pour turntable and the drain turntable. An infrared camera, protected from radiation, will be installed in the melt cell so that both turntables can be viewed. The camera will view the upper half of the canister. The image will be viewed on color monitors outside the melt cell and in the control room. Based on the image the canister fill level will be manually controlled.

Demonstration of the Glass Level Monitoring System

During the non-radioactive portion of the Startup Test Program, the infrared level detection will be used on the melter pour turntable. Results of the

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.6 FILL HEIGHT SPECIFICATION

demonstration of control will be reported in Volume 10 of the Waste Form Qualification Report (WQR).

Documentation

Volume 10 of the Waste Form Qualification Report will include reports on development of the method of controlling the glass level in a canister during filling. Volume 10 will also contain the results of testing performed during the Startup Test Program to determine how well the glass pouring system can be controlled and to demonstrate the glass level monitoring system. The uncertainty associated with the reported fill height (see below) will also be described in Volume 10.

The Production Record for each canistered waste form will include the fill height, determined from the infrared level detection system, of that canistered waste form.

If a particular canistered waste form is not filled to a height equivalent to 80% of the canister volume, the Production Record for that canister will clearly indicate this underfilled condition. It is anticipated that an underfilled canister will be a rare occurrence. However, an underfilled canister will probably be produced during melter draining since the melter holds approximately 4.5 canister volumes of glass. The life expectancy of the melter is at least 2 years. Thus, melter draining should occur only once every 2 years (~ 820 canistered waste forms at design production rate). The DWPF will also notify DOE-SR that the canister is underfilled and therefore non-conforming. However, the DWPF will normally not take any further action (e.g., attempting to reinitiate filling after the canister has been removed from the turntable) to remedy the non-conforming condition if this is the only specification violated. The DWPF considers this use-as-is disposition to be acceptable based on the following:

- Free volume is not a safety or waste isolation issue for the repository. Hence, reliability of processing in the DWPF and compliance with specifications in the WAPS which are related to safety or waste isolation should take precedence.

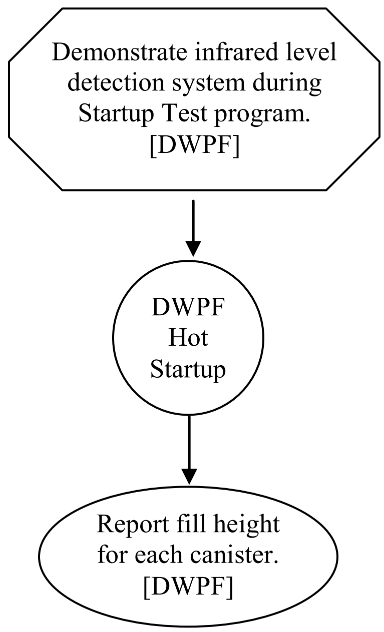
- Although it might be possible to fill some underfilled canisters, there will be some cases (especially when the canister is only slightly under-filled) when this cannot be done without risking overfill of the canister and consequent harm to processing equipment.

- Even in those cases where filling is possible, it could compromise the DWPF's ability to comply with other specifications which are important for safety and waste isolation such as preventing foreign materials from entering the canister and decontamination.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.6 FILL HEIGHT SPECIFICATION

FIGURE 5.350.1 Tasks planned to satisfy Specification 3.6, Fill Height Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

The level of non-fixed (removable) radioactive contamination on the exterior surface of each canistered waste form may be determined by wiping an area of 300 cm2 of the surface concerned with an absorbent material, using moderate pressure, and measuring the activity on the wiping material. At the time of shipment, the radioactive contamination on the wiping material shall not exceed 22,000 dpm/100 cm^2 of canister surface wiped for beta and gamma emitting radionuclides and 2,200 dpm/100 cm^2 of canister surface wiped for alpha emitting radionuclides. Sufficient measurements shall be taken in the most appropriate locations to yield a representative assessment of the non-fixed contamination levels.

In addition, the Producer shall visually inspect each canistered waste form and remove visible waste glass from the exterior before shipment.

The Producer shall describe the method of compliance in the WCP. The Producer shall provide the non-fixed contamination level results in the Storage and Shipping Records.

Compliance Strategy

After filling, canistered waste forms will be visually inspected for waste glass on the external surfaces of the canister. Any visible waste glass observed on the exterior of the canistered waste form will be removed by means of a needle gun or other demonstrated technique. The canistered waste form will be decontaminated by frit slurry blasting.[1-3] The DWPF will comply with the specification by smear testing the canister in the shipping facility prior to shipment. (It must be noted that this facility does not yet exist). Additional assurance that the canistered waste forms do not exceed the specified contamination levels will be provided by smear tests of the canister's external surfaces in the DWPF during production.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.400.1. They are

- Development and testing of a method to remove any visible waste glass from the canister exterior, before it leaves the vitrification building.
- Development of a method to decontaminate the canistered waste form.
- Development of the technical bases for smear procedures in the DWPF, and design of a smearing system in a shipping facility.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

- Design and qualification testing of the shipping facility.

Removal of Visible Glass

The canistered waste forms, while in the Melt Cell after filling, will be visually inspected for adhering glass. If any adhering glass is detected, it will be removed after the inner canister closure is installed and before the canister is transferred from the Melt Cell to the Canister Decontamination Cell. Use of a needle gun (e.g., Von-ARX needle gun distributed by Marindus Co.) to remove adhering glass from the canister surface has been demonstrated. Remote methods of supporting the needle gun and of removing the glass particles generated during operation of the needle gun will be developed, and tested.

Canister Decontamination

Air-injected frit slurry blasting has been shown to be the most efficient method of canister decontamination investigated.[2] It effectively cleans the canister external surfaces, and the waste generated is recycled to the vitrification process. In this process, the canister is placed in the DWPF Canister Decontamination Chamber. In this device, a slurry of glass frit suspended in water is pumped to blast nozzles which accelerate the motion of the frit slurry toward the canister surface by high pressure air. After frit blasting, the canister surface is rinsed with a water jet, and then air dried. The canister is lifted and rotated during these procedures by a Canister Manipulating Mechanism (CMM). Preliminary process parameters to be used in the DWPF[3] have been identified and demonstrated by blasting 26 simulated waste glass canisters using the actual DWPF Canister Decontamination Chamber. This process will be tested further during the Startup Test Program.

Technical Bases for Smearing

After frit blasting, the canister will be checked for residual contamination. Smear pads 3.18 cm (1.25 in) in diameter will be used to smear the surface of each rotating canister. Each smear pad contacts an area of ~ 100 cm^2 (15 in^2).

Savannah River National Laboratory (SRNL) is carrying out a program to provide the technical bases for development of smear test procedures. In this program variables such as the amount of force applied to the pad, the method of application of the force, the area actually contacted by the smear pad, the distance the smear pad travels along the canister surface, and the curvature of the canister surface are being examined. Based on the results, DWPF will develop smear testing procedures for operation of the equipment (described below) in the vitrification building. The SRNL work and experience with smear testing in the DWPF will be used to design a smearing system and smearing regimen (% coverage, number of smears per unit area) for the shipping facility.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

The canister will be transferred to the Weld Test Cell for final closure only after all smear test results are within the specified limits. If any smear exceeds specified limits, the canister will be decontaminated again by slurry-blasting until the contamination level is within the specified limits. (During production, DWPF will use the tighter limits of 2,200 dpm/100 cm^2 beta/gamma and 220 dpm/100 cm^2 alpha.) A confirmatory smear test will also be made in the Weld Test Cell prior to transfer to interim storage in the DWPF's Glass Waste Storage Building. A pneumatic transfer system is used to transfer smear samples out of the shielded cells. The smear test is performed remotely using manipulators with the aid of CCTV cameras and by direct observation through shield windows. The control stations and the radio bench hood for smear sample counting are located outside the cell in close proximity to shield windows.

Canister Shipping Facility

Sometime in the future, a canister shipping facility will be designed and built. The technical bases for smearing described above, as well as the experience with the smear testing systems in the DWPF, will be used as design input for the facility. Once built, it is anticipated that a qualification program will be carried out, to ensure that the Shipping Facility's procedures and equipment will satisfy the specification.

Documentation

Volume 11 of the Waste Form Qualification Report (WQR) will include a report on the decontamination method, and the technique for removing visible waste glass from the canister exterior. The WQR will also include the results of the program to develop the technical bases for the smear test procedures.

The DWPF will report, in the Storage and Shipping Records, all smear test results for each canister. If the canister contamination level cannot be brought down to the DOE specified values, then the canistered waste form will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300.

References

1. W. N. Rankin, "Decontamination Processes for Waste Glass Canisters," Nuclear Technology, 59, 314-20 (1982).

2. C. R. Ward, **Selection and Development of Air-Injected Frit Slurry Blasting for Decontamination of DWPF Canisters**, USDOE Report DP-1692, E. I. Du Pont de Nemours, Inc., Savannah River Laboratory, Aiken, SC 29808 (1984).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

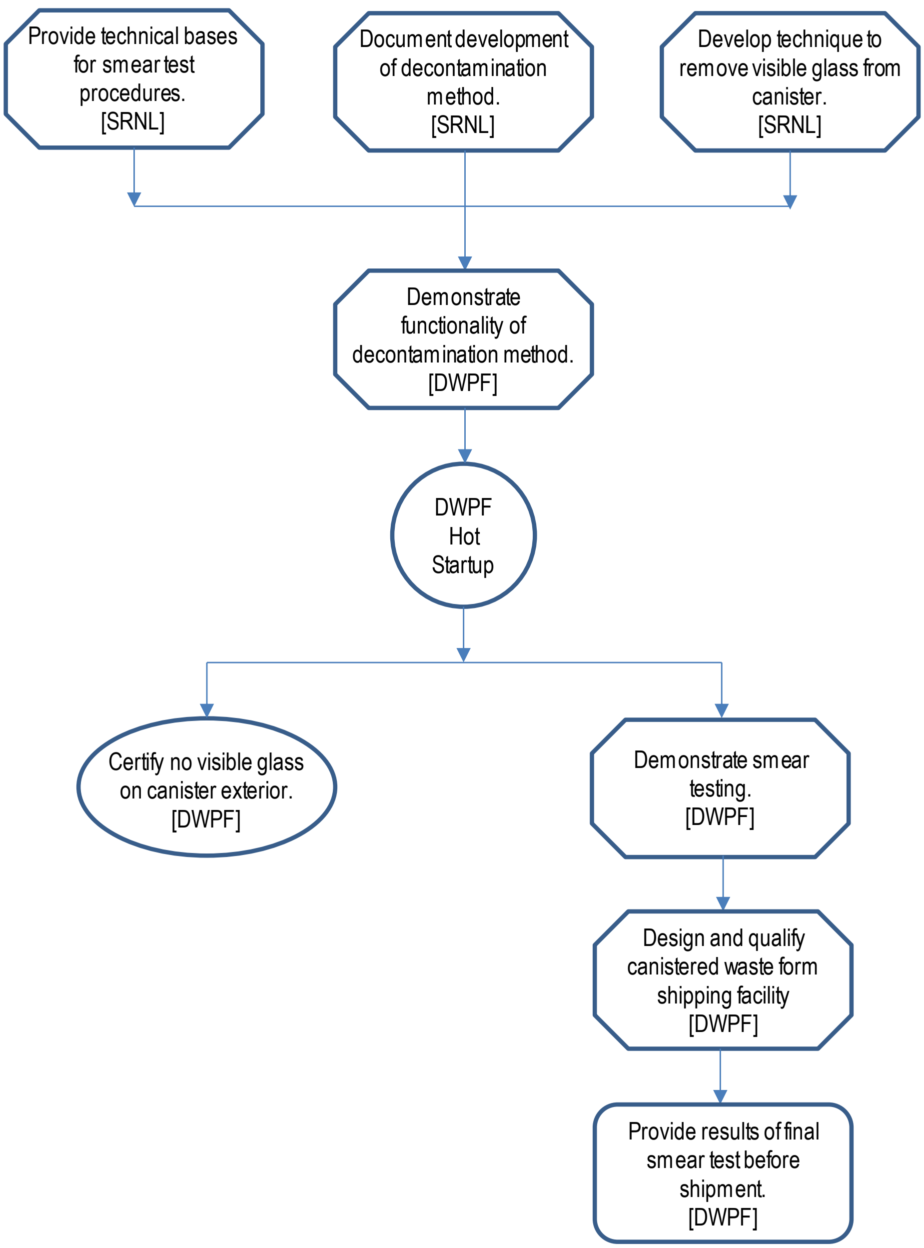
ITEM TITLE: 3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

3. A. H. Harris and C. R. Ward, **Development and Demonstration of the DWPF Canister Decontamination Process Using Frit Slurry Blasting**, USDOE Report DP-MS-86-128, E. I. Du Pont de Nemours, Inc., Savannah River Laboratory, Aiken, SC 29808 (1986).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

FIGURE 5.400.1 Tasks planned to satisfy Specification 3.7, Specification for Removable Radioactive Contamination on External Surfaces.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.1 HEAT GENERATION PROJECTIONS

3.8 HEAT GENERATION SPECIFICATION

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

3.8.1 Heat Generation Projections

The Producer shall document in the WQR the expected thermal output of the canistered waste forms and the range of expected variation for each waste type, indexed to the year 2015. The method to be used for demonstrating compliance shall be described by the producer in the WCP. Projections for compositions not available for reporting in the initial WQR shall be included in an addendum to the WQR.

Compliance Strategy

The expected thermal output and the range of expected variations for the canistered waste forms will be calculated based on the radionuclide inventory projections described in Part 3, Item 300.

Implementation

As shown in Figure 5.450.1, this specification will be satisfied by

- Providing the radionuclide inventory projections as described in Part 3, Item 300.

- Converting the radionuclide inventory projections into projections of heat generation rates for each waste type. This will be done by multiplying the amount of each radionuclide by its specific thermal output, using standard values.[1]

- Estimating the range of values for each waste type by bounding calculations.

Calculation of Heat Generation Rates

For each of the waste types identified in Part 3, Item 300, the heat generation rate will be calculated from the radionuclide inventory of the glass, using standard values[1] of the thermal output per unit activity for each radionuclide. The radionuclides which will be included in performing this calculation will be all of those radionuclides to be reported to the repository as part of the radionuclide inventory* (see Part 3, Item 400), and any other short-lived radionuclides in the Design-Basis waste which significantly contribute to the heat generation rate. Preliminary

* Those with half-lives greater than 10 years and which constitute at least 0.01% of the radionuclide inventory at any time up to 1100 years after production.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.1 HEAT GENERATION PROJECTIONS

calculations indicate that the latter will be of importance only for waste which is 10 years old or less.

Estimation of Ranges of Heat Generation Rates

The range of the heat generation rates for each waste type will be provided through simple bounding calculations. The lower bound for each waste type is assumed to be glass which contains no radionuclides, either due to melter startup (when actual waste glass is displacing simulated waste glass), or due to flushing operations (e.g., when a melter is about to be taken out of service). The upper bound will be estimated by assuming a 90% fill of a glass which contains the maximum amount of waste which will produce an acceptable glass (based on the algorithms described in Part 3, Item 500).

Documentation

Volume 3 of the Waste Form Qualification Report will detail the expected thermal output and the range of expected variations for the canistered waste forms.

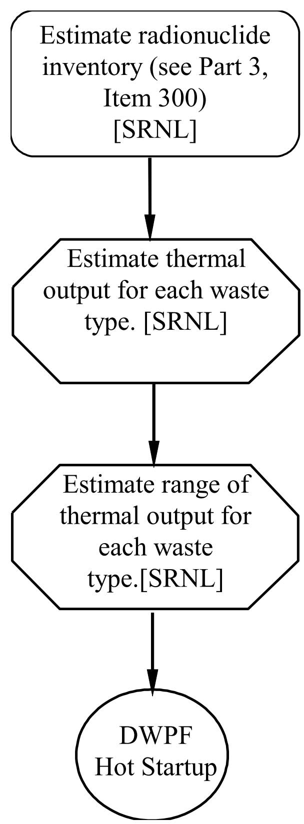
References

1. **Integrated Data Base for 1991: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics**, USDOE Report RW-0006, Revision 7.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.1 HEAT GENERATION PROJECTIONS

FIGURE 5.450.1 Tasks planned to satisfy Specification 3.8.1, Heat Generation Projections.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.2 HEAT GENERATION AT YEAR OF SHIPMENT

3.8 HEAT GENERATION SPECIFICATION

3.8.2 Heat Generation at Year of Shipment

The Producer shall report in the Storage and Shipping Records the estimated heat generation rate for each canistered waste form. The Producer shall describe the method for compliance in the WCP.

Compliance Strategy

The heat generation rate of each canistered waste form will be calculated based on the radionuclide inventory described in Part 3, Item 400, augmented by analytical results for short-lived radionuclides (measured for process safety reasons). Thus, in the Storage and Shipping Records, the DWPF will report the average heat generation rate, and the standard deviation, for all the canisters produced from a given macro-batch. If, at time of proposed shipment, a canistered waste form has a heat generation rate greater than 1500 watts, the canistered waste form will be identified as a nonconforming item, and dispositioned as outlined in Part 6, Item 300.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.500.1. They are to calculate the heat generation rate from the radionuclide inventory, and to estimate the error in the method of calculation.

Calculation of Heat Generation Rate

The heat generation rate will be calculated from the radionuclide inventory of the glass, using standard values[1] of the thermal output per unit activity for each radionuclide. The radionuclides which will be included in performing this calculation will be all of those radionuclides to be reported to the repository as part of the radionuclide inventory[*] (see Part 3, Item 400), and any other radionuclides analyzed for process safety purposes in the DWPF (e.g. Pr-144, Eu-154, or Eu-155). Preliminary calculations indicate that the latter will be of importance only for waste which is 10 years old or less.
Because the radionuclide inventory is reported on a macro-batch basis, the heat generation rate will also be reported in that manner. Each radionuclide inventory value estimated from process batches for a given macro-batch will be used to generate a heat generation rate. These heat generation rates will then be averaged, and a standard deviation calculated. This average heat generation rate and standard deviation will then be reported for each canister of the macro-batch.

If the heat generation rate exceeds 1500 watts (taking into account the uncertainty in the calculated value) at time of shipment of the canister from

[*]Those with half-lives greater than 10 years and which constitute at least 0.01% of the radionuclide inventory at any time up to 1100 years after production.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.2 HEAT GENERATION AT YEAR OF SHIPMENT

the DWPF, the canister will be identified as a nonconforming item, and then dispositioned according to the procedure outlined in Part 6, Item 300.

Estimates of Error

Preliminary calculations have already been performed for the Design-Basis glass. At time of production, the heat generation rate of the glass is calculated to be 710 watts/canistered waste form. The dominant source of error in the calculation is the radionuclide inventory. The current estimates of uncertainties in the radionuclide inventory in Part 3, Item 400, indicate that the calculated heat generation rate will be within 10% of the actual value (There will be a slight bias in the reported values; less than about 15 watts for the worst case).

Documentation

Volume 12 of the Waste Form Qualification Report will include a description of the heat generation rate calculation, the results of tests to determine the error in the reported values, and an estimation of the error.

The Storage and Shipping Record for each canistered waste form will include the heat generation rate as calculated from the radionuclide inventory of the glass.

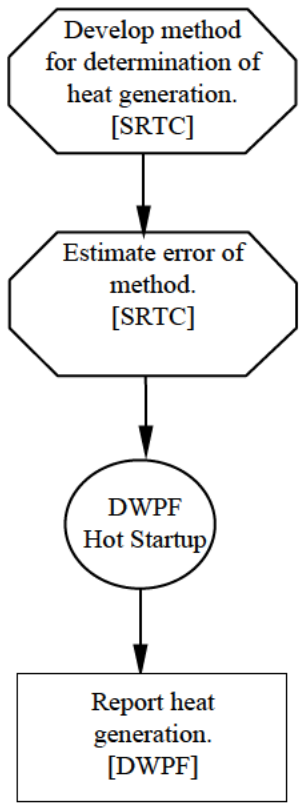
References

1. **Integrated Data Base for 1991: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics**, USDOE Report RW-0006, Revision 7 (1992).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.2 HEAT GENERATION AT YEAR OF SHIPMENT

FIGURE 5.500.1 Tasks planned to satisfy Specification 3.8.2, Heat Generation at Year of Shipment.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.1 PROJECTIONS OF DOSE RATES

3.9 SPECIFICATION FOR MAXIMUM DOSE RATES

The canistered waste form shall not exceed a maximum surface (on contact) gamma dose rate of 10^5 rem/hr and a maximum neutron dose rate of 10 rem/hr, at the time of shipment.

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.

Compliance Strategy

The expected dose rates and the range of expected variation will be calculated based on the radionuclide inventory projections described in Part 3, Item 300.

Implementation

As shown in Figure 5.500.1, this specification will be satisfied by

- Providing the radionuclide inventory projections for each waste type as described in Part 3, Item 300.
- Converting the radionuclide inventory projections into projections of dose rates for each waste type.
- Estimating the range of values for the canistered waste forms of each waste type by bounding calculations.

Calculation of Dose Rates

The values required by this specification will be determined by converting the radionuclide inventory projections described in Part 3, Item 300, into corresponding projections of neutron and gamma dose rates. This will be done by multiplying the amount of each radionuclide by its dose rate per curie. Self-shielding and shielding by the canister will also be taken into account.

Preliminary estimates of the maximum dose rates of DWPF canistered waste forms have already been made. These have been calculated from the composition and radionuclide inventory of the Design-Basis waste glass. These calculations are summarized in Table 5.550.1.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.1 PROJECTIONS OF DOSE RATES

Estimation of Ranges of Dose Rates

The range of the dose rates for the canistered waste forms of each waste type will be provided through simple bounding calculations. The lower bound will be estimated by assuming that the glass contains virtually no waste (e.g., melter changeout). The upper bound will be estimated by assuming a 90% fill of a glass which contains the maximum amount of waste which will produce an acceptable glass.

Documentation

Volume 3 of the Waste Form Qualification Report will include a report on the projections of gamma and neutron dose rates, and their expected variations. Results of tests of the calculational methods will also be reported, including the experimental verification of the SRS neutron dose rate calculations.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.1 PROJECTIONS OF DOSE RATES

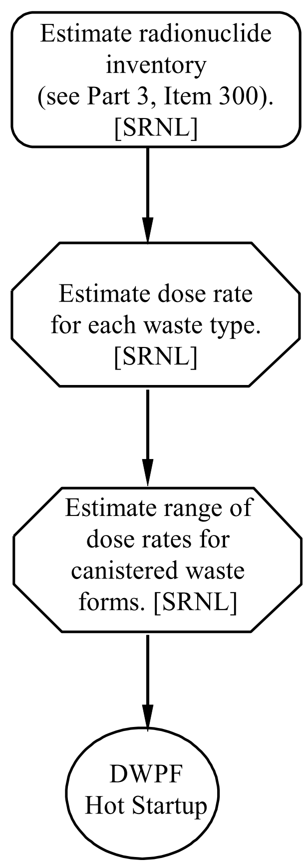
TABLE 5.550.1 Calculated maximum gamma and neutron dose rates of DWPF canistered waste forms (based on Design-Basis Glass).

Distance (ft)	Gamma(R/hr)	Neutrons(mrem/hr)	Total (R/hr)
Surface	5570	420.	5570
1	2190	97.	2190
3	900	42.	900
5	470	23.	470
10	160	7.5	160
20	44	2.5	44
30	20	1.0	20
50	7	0.5	7
75	3	---	3
100	2	---	2

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.1 PROJECTIONS OF DOSE RATES

FIGURE 5.550.1 Tasks planned to satisfy Specification 3.9.1, Projections of Dose Rates.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.2 DOSE RATES AT TIME OF SHIPMENT

3.9 SPECIFICATION FOR MAXIMUM DOSE RATES

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.

Compliance Strategy

The DWPF will comply with the specification be measuring the dose rates from canistered waste forms in the shipping facility prior to shipment. (It must be noted that this facility does not yet exist.) Additional assurance that the canistered waste forms do not exceed the specified dose rates will be provided by dose rate measurements in the DWPF.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.600.1. They are

- Identification of methods to measure the neutron and gamma dose rates of the canistered waste form.

- Design, construction, and qualification testing of the shipping facility.

Measurement of Gamma and Neutron Dose Rates

Prior to the initiation of production, methods for measuring the gamma and neutron dose rates of the canistered waste forms will be identified. Standard techniques and instruments will be adapted to this task. Appropriate technologies will be described in the Waste Form Qualification Report, to establish the existence of methods which could be successfully deployed in a Shipping Facility.

Design and Qualification Testing of the Shipping Facility

Sometime in the future, a canister shipping facility will be designed and built. The instruments used at SRS to measure gamma and neutron dose rates, as well as the operating experience with those instruments, will be used as design input for the facility. Once built, it is anticipated that the procedures and equipment will satisfy the specification.

Documentation

Volume 12 of the Waste Form Qualification Report will include a description of instruments which could be used to measure the gamma and neutron dose rates of DWPF canistered waste forms. Eventually, the results of qualification testing of a Shipping Facility will be added to Volume 12.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.2 DOSE RATES AT TIME OF SHIPMENT

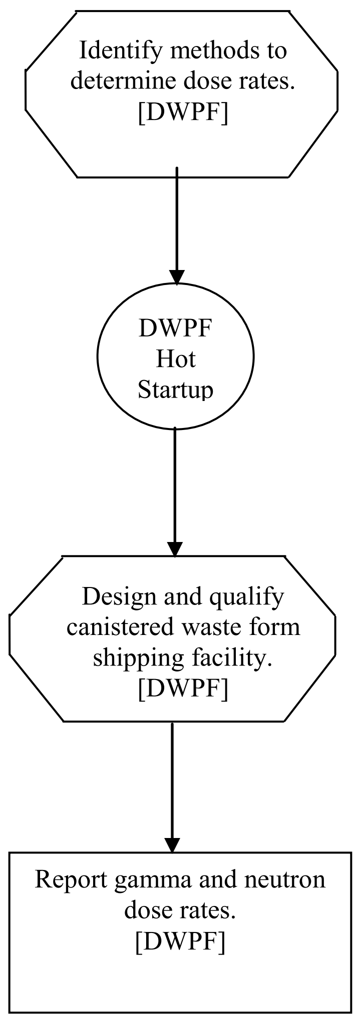
The Storage and Shipping Record for each canistered waste form will include the gamma and neutron dose rates of the canistered waste form as determined in the DWPF shipping facility.

If the measured dose rates exceed 10^5 R/hr surface gamma dose rate, or 10 rem/hr neutron dose rate, then the canistered waste form will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9.2 DOSE RATES AT TIME OF SHIPMENT

FIGURE 5.600.1 Tasks planned to satisfy Specification 3.9.2, Dose Rates at Time of Shipment.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

3.10 SUBCRITICALITY SPECIFICATION

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 concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The calculated effective multiplication factor, k_{eff}, shall be sufficiently below unity to show at least a 5% margin 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 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.

Compliance Strategy

The DWPF will comply with the specification by performing bounding calculations to show that the effective multiplication factor for a canistered waste form will be much less than 1.

Implementation

The tasks sufficient to satisfy this specification are outlined in Figure 5.650.1. They include

- Development of the radionuclide inventory projections, as described in Part 3, Item 300.

- A determination of the nuclear characteristics of DWPF canistered waste forms, based on the projected radionuclide inventories. This includes identification of bounding case(s).

- Calculation of k_{eff} for the bounding case(s).

Bounding Cases for DWPF Canistered Waste Forms

A k_{eff} calculation was included in the DWPF facility's nuclear safety analysis prior to finalization of the DWPF design. The calculation was made on both Design-Basis glass, and on a glass containing twice as much fissionable material as the Design-Basis glass. An infinite array of canisters was assumed in the calculations which would bound any finite array of canisters in any arrangement including double stacking of canisters, and flooding was considered. These would constitute at least two unlikely, independent, and concurrent or sequential changes in the conditions essential to nuclear criticality safety.

In all cases the calculated neutron multiplication factor was quite low, k_{eff} < 0.15. Doubling the plutonium and the ^{235}U concentrations (with the other constituents reduced proportionately for normality), increased k_{eff} to 0.273, but this value is low enough to provide an ample safety margin.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

The calculations were repeated for three glass compositions which represent those expected to be produced in the DWPF during the first six to eight years of production (Batches 1, 2 and 3).

Infinite neutron multiplication factor calculations for these three glass compositions were made with the computer code HRXN with Hansen-Roach neutron cross sections,[1] and other cross sections having the same energy group structure, generated at Oak Ridge National Laboratory, and furnished with the KENO-IV Monte Carlo criticality code.[2] The mixtures were all assumed to be uniform in composition and infinite in amount. An infinite array of canisters was also assumed in the calculations.

For the Batch 1, 2 and 3 glasses the calculated values of k_{eff} were 0.0019, 0.0066, and 0.0073, respectively. Doubling the concentration of the fissile plutonium isotopes (^{239}Pu and ^{241}Pu) while retaining the other plutonium isotopes at the same concentration, and doubling the concentration of the fissile uranium isotopes (^{233}U and ^{235}U) while reducing the concentration of ^{238}U, increased the calculated values of k_{eff} for Batch 1, 2, and 3 to 0.0026, 0.0081, and 0.0092, respectively. These values of k_{eff} provide ample margin for uncertainties.

The calculated values of k_{eff} would be increased if appreciable amounts of water were interspersed in the infinite array of glass canisters considered in these calculations. However, the fissile isotope content of the glass is so low that it would not be possible to increase k_{eff} to exceed a critical value without introducing at least two orders of magnitude more fissile isotopes.

Documentation

Volume 3 of the Waste Form Qualification Report will include a report on the calculations showing that the effective multiplication factor of a canistered waste form will be much less than 1. The report will include sufficient information on the nuclear characteristics of the canistered waste form to enable the repository designer to confirm subcriticality under repository storage conditions.

References

1. G. E. Hansen and W. H. Roach, **Six and Sixteen Group Cross Sections for Fast and Intermediate Critical Assemblies**, USAEC Report LAMS-2543 (1961).

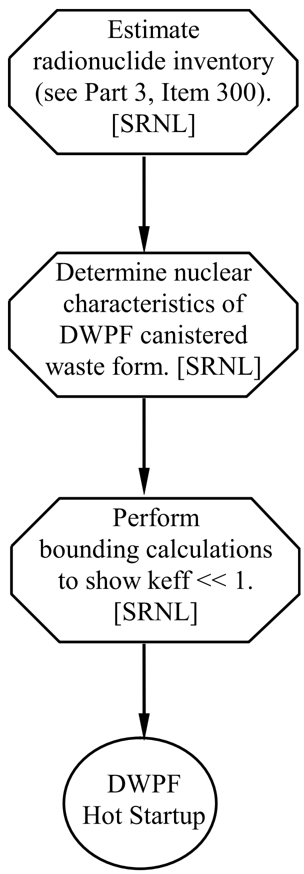
2. L. M. Petrie and N. F. Cross, **KENO-IV - An Improved Monte Carlo Criticality Program**, USAEC Report ORNL-4938, Oak Ridge National Laboratory, Oak Ridge, TN (1975).

3. H. C. Honeck, **The JOSHUA System**, USERDA Report DP-1380, E. I. DuPont de Nemours and Co., Inc., Savannah River Plant, Aiken, SC (1975).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

FIGURE 5.650.1 Tasks planned to satisfy Specification 3.10, Subcriticality Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.11 SPECIFICATIONS FOR WEIGHT AND OVERALL DIMENSIONS

3.11 SPECIFICATIONS FOR 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. 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 Specification

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

3.11.2 Specification for Overall Dimensions

The dimensions of the canistered waste form shall be such that, at the time of delivery, the canistered waste form will stand upright without support on a flat horizontal surface and will fit completely 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 estimate in the WQR the minimum canister wall thickness of the filled, decontaminated canister. The Producer shall also provide in the WQR an estimate of the amount of canister material that is removed during surface decontamination and the basis for that estimate. The Producer shall document the unfilled canister wall thickness in the Production Records.

Compliance Strategy

The final weight of each DWPF canistered waste form will be measured in a shipping facility, prior to shipment from the DWPF to a repository. Measurements of non-radioactive canistered waste forms produced under conditions representing the range of those expected in the DWPF show that the vitrification process does not significantly affect the dimensions of the canistered waste form (see Part 4, Item 400). Thus, the DWPF will ensure that the overall dimensions of the canistered waste form are within the specified limits by controlling the dimensions of the purchased canister. The minimum wall thickness is 0.340 inches (0.86 cm), based on the canister procurement specifications and the fact that the vitrification process does not reduce canister wall thickness.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.700.1. These are

• Development of a requirement for the canister wall thickness, which has been included in the canister procurement specifications. This also includes identification of canister inspection requirements to ensure that the specification is met at the vendor's shop.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.11 SPECIFICATIONS FOR WEIGHT AND OVERALL DIMENSIONS

- Determination of the amount of material removed from the canister wall.
- Determination of the change in canister wall thickness and overall dimensions during glass pouring at the pilot plant facilities.
- Design and qualification testing of a shipping facility.

Canister Procurement Specifications

The DWPF has developed detailed canister procurement specifications which specify the wall thickness and overall dimensions of canisters. In addition, inspection requirements are being defined, to ensure that the purchased canisters actually meet specifications before they leave the vendor's shop.

Change in Dimension During Pouring

As discussed in Part 4, Item 400, seven prototypical canisters were carefully measured and then filled under both design basis (continuously filling) and the most likely upset (pouring rapidly in short bursts) conditions. The calculated diameter of a cylinder large enough to contain the canister, taking into account ovality and bow was determined to be 24.21 inches (61.49 cm). This maximum cylinder diameter is within the specified limit of specification 3.11.2. The WQR will provide the technical basis for this conclusion, and the details of the measurements and calculations.

The weights of the prototypical canistered waste forms were also measured. The average weight of the glass was ~1680 kg. The average weight of the canister was ~500 kg. Thus, the total weight of each simulated canistered waste form was ~2180 kg, indicating that the DWPF should have little difficulty in meeting the weight specification.

If it was necessary to use a repair cap for the final canister weld (see Part 4, Item 200) the canistered waste form would not fit within the specified right circular cylinder. This canistered waste form would then be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300.

Metal Removal During Decontamination

Based on process development work at SRTC, a single slurry frit blasting cycle will remove 70 g of canister material (metal and contaminated oxides), or approximately 2 mg/cm^2 of canister surface area (This corresponds to a penetration of ~0.2 µm.). It has been shown that a conservative estimate of the minimum metal removal required to achieve the specified level of decontamination is 1 mg/cm^2.

Design, and Qualification Testing of the Shipping Facility

The weight of the canistered waste form will be determined in a canister shipping facility prior to shipment to a repository. In addition, the overall dimensions of the canistered waste form will also be verified in the shipping facility prior to shipment. This will be done either through use of a

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.11 SPECIFICATIONS FOR WEIGHT AND OVERALL DIMENSIONS

template to ensure the right cylindricality and proper diameter and length of the canister, or through measurements. No dimensional changes in the canistered waste form are expected between the time of shipment from DWPF and the time of delivery at the repository. It is anticipated that a qualification program of the systems to measure canister weight and the overall dimensions of the canister will be carried out, to ensure that the procedures and equipment will satisfy the specification.

Documentation

Volume 8 of the Waste Form Qualification Report will reference the canister procurement specifications, and inspection procedures. The WQR will also include a report on the effect of the vitrification process on the canistered waste form dimensions. A report on the amount of material removed during decontamination will also be included.

The Production Record for each canistered waste form shall contain the as-purchased wall thickness of the canister.

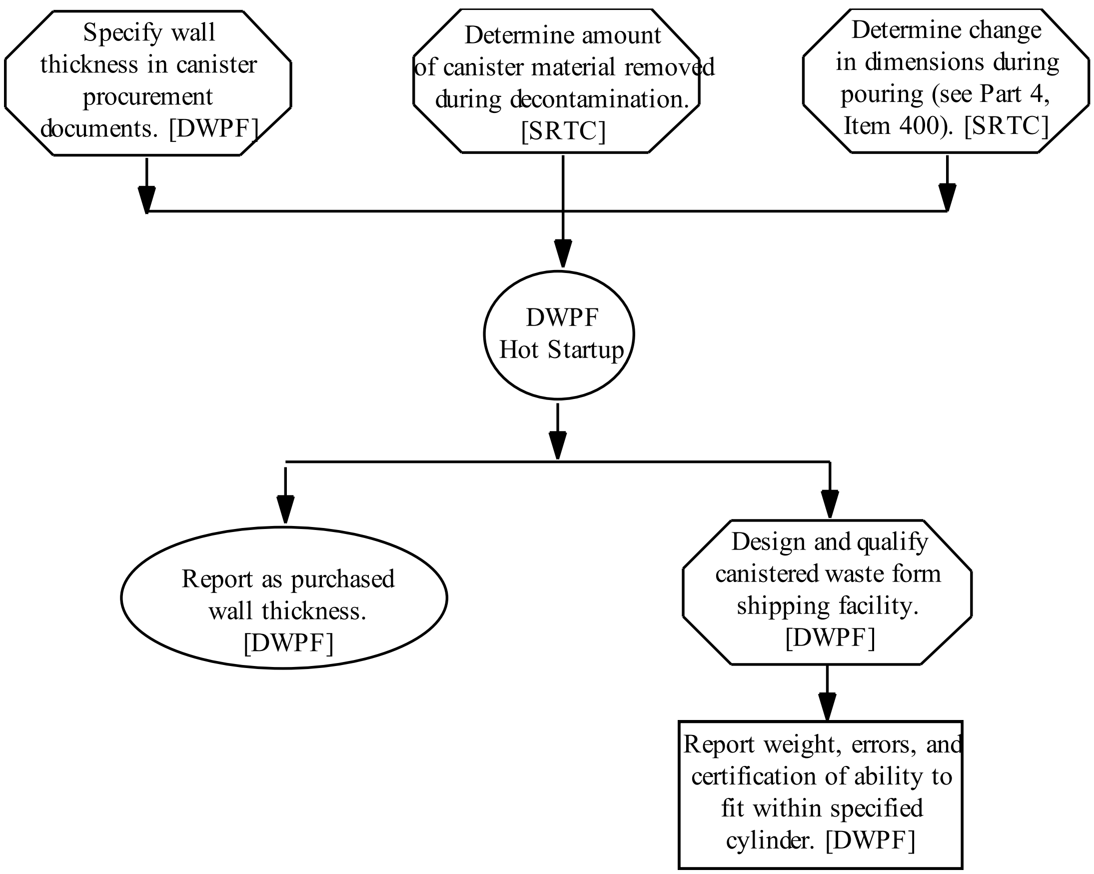
The Storage and Shipping Record for each canistered waste form will include the weight and a determination of the ability of the canister to fit without forcing into the specified cylinder. The weight will be obtained by weighing in the shipping facility. The ability of the glass-filled canisters to fit without forcing into the specified cylinder will be certified at time of shipment either based on the ability of the canister to fit, without forcing, into a template of the specified cylinder, or based on calculation of the minimum cylinder which can contain the canister.

If the canister weight exceeds the specified amount or the canister cannot fit in the specified cylinder, then the canistered waste form will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.11 SPECIFICATIONS FOR WEIGHT AND OVERALL DIMENSIONS

FIGURE 5.700.1 Tasks planned to satisfy Specification 3.11, Specifications for Weight and Overall Dimensions.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.12 DROP TEST SPECIFICATION

3.12 DROP TEST SPECIFICATION

The canistered waste form shall be capable of withstanding a 7 meter drop onto a flat, essentially unyielding surface without breaching or dispersing radionuclides (leaktight < $1x10^{-4}$ atm-cc/sec helium). The Producer shall describe the method of compliance in the WCP and provide test results and any supporting analyses in the WQR. The test results shall include information on measured canister leak rates and canister deformation after the drop.

Compliance Strategy

The DWPF canister design has been qualified by testing canisters filled under both design-basis and the most likely process upset conditions (see Part 5, Item 700). The results will be reported in Volume 8 of the Waste Form Qualification Report. The DWPF will ensure a consistently robust canister (one able to withstand a 7 m drop) through control and verification of canister materials and fabrication (see Part 4, Items 100 and 200).

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.750.1. They are

- Preparation of canisters for testing. Prototypical canisters procured according to the DWPF canister procurement specifications were filled under both reference process conditions, and under the most likely process upset conditions.

- Dropping the canisters 7 m onto an unyielding surface.

- Measurement of canister deformation and leak rate, to establish robustness of canister design.

- Control of the canister procurement process to ensure that the canisters used are consistently robust. This is achieved by ensuring that the canister satisfies the canister procurement specifications, as described in Part 4, Items 100 and 200, Part 4, Item 400, and Part 5, Item 700.

Production of Canisters for Testing

SRTC has previously dropped DWPF-like canisters from 9 m, in a variety of orientations.[1] No failures of DWPF-like canisters due to impact testing have ever been observed. This has been an important factor in finalizing the canister procurement specifications.

Canisters of the current DWPF design were procured for SRTC by the DWPF, according to the current canister specifications (see Part 4, Items 100 and 200, and Part 5, Item 700). Seven canisters were filled, four under reference process conditions, and three under conditions representing the most likely upset scenario (batch pouring), to the same levels expected for DWPF canisters (see Part 5, Item 300). These canisters were frit blasted, simulating the

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.12 DROP TEST SPECIFICATION

decontamination process, and sealed in the same manner as in the DWPF (in some cases, with actual DWPF equipment).

Testing of Canisters and Effects of Impacts[2]

Strain circles were applied to the canister surface to indicate the magnitude of the strains exerted on the canisters during impact. These canisters were dropped from 7 m, in two orientations:

- The most likely - on the bottom.
- The most severe - on the head at an angle.

Each canister was tested by dye penetrant methods. Helium leak rate measurements were also made. All of the canisters survived the impacts without breaching.

Documentation

Volume 8 of the Waste Form Qualification Report (WQR) will include a report on the bases of the drop tests, the results of the drop tests, and the effects of the impacts on the canister's leaktightness, dimensions, and integrity.

References

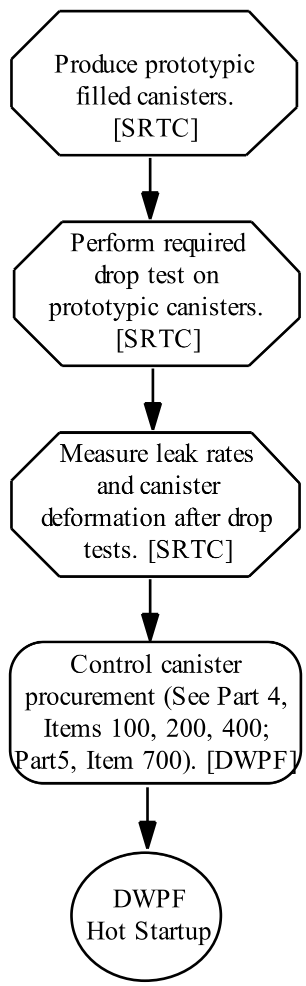
1. J. W. Kelker, **SRL Canister Impact Tests**, USDOE Report DP-1716, E. I. DuPont de Nemours, Inc., Savannah River Laboratory, Aiken SC (1986).

2. K. M. Olson, J. M. Alzheimer, **Defense Waste Processing Facility Canister Impact Testing**, Pacific Northwest Laboratory, Richland, WA (1989).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.12 DROP TEST SPECIFICATION

FIGURE 5.750.1 Tasks planned to satisfy Specification 3.12, Drop Test Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

3.13 HANDLING FEATURES SPECIFICATION

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 in loading and unloading a transportation cask with a standard HLW canister at the repository, which satisfies 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, and when engaged with the flange, shall be capable of raising and lowering a (standard) canistered waste form in a vertical direction.

(c) The 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.

(d) The grapple shall be designed to prevent an inadvertent release of a suspended (standard) 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.

Compliance Strategy

The DWPF has designed a canister grapple which meets the design requirements above. Testing of the grapple has shown that it meets the specification. In compliance with the specification, the DWPF will also supply designs of the canister flange and grapple to the repository. The canister procurement specifications require concentricity of the canister neck and flange.

Implementation

The tasks which have been planned to satisfy this specification are outlined in Figure 5.800.1. They are:

- Design of the canister lifting flange, and determination of its maximum capacity.

- Design and testing of the canister grapple.

- Specification of requirements for the flange (including concentricity requirements) in the canister procurement specifications.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

Canister Lifting Flange

The lifting flange geometry for the DWPF canister is shown in Figure 5.800.2; more detail is available from DWPF drawing #W832094, including method of attachment to the canister. This drawing is referenced in the canister procurement specifications, which require that the canister neck and lifting flange be concentric. Calculations estimate its maximum loading capacity as 15,000 lbs. These calculations will be included in the Waste Form Qualification Report.

Design and Testing of Canister Grapple

The canister lifting grapple is specific for the DWPF canister and was developed by Remote Technology Corp. (REMOTEC) of Oak Ridge, TN.[1] The canister grapple is capable of remotely picking up a canister, transporting it to a new location and releasing. The grapple lifting lug configuration and operation is designed to minimize canister damage which could affect the welding ground path during final canister closure operations. The grapple is designed without any electrical power source and uses a mechanical linkage to positively secure the canister. A more detailed description of the grapple's design features, and of the testing of the grapple, will be provided in the Waste Form Qualification Report.

Documentation

Volume 8 of the Waste Form Qualification Report will include descriptions and detailed drawings of the designs of the lifting flange and grapple. Test data from development and operability testing of the grapple will be included as well. A report detailing the calculation of the loading capacity of the canister neck and lifting flange will also be provided.

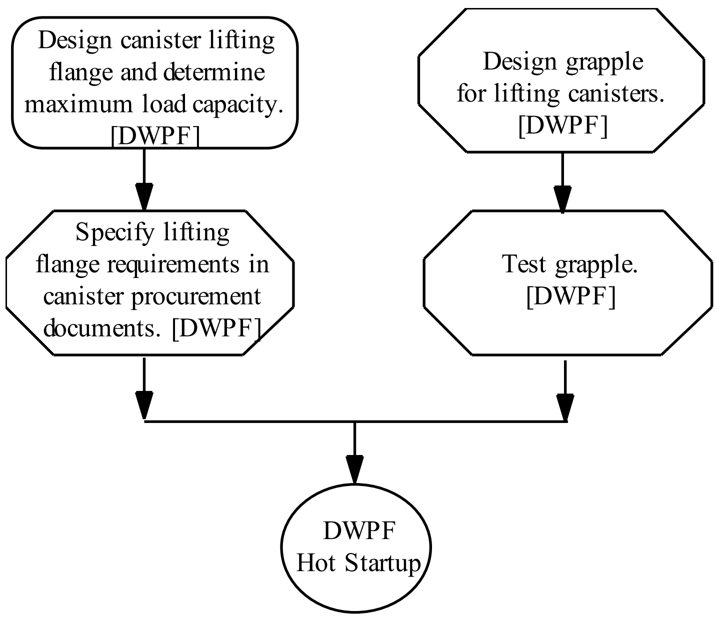
References

1. K. L. Walker, J. R. White, K. A. Farnstrom, R. E. Eversole, "Canister Grapple for the Defense Waste Processing Facility," **Proceedings, 34th Conference on Remote Systems Technology**, American Nuclear Society, 75-9 (1986).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

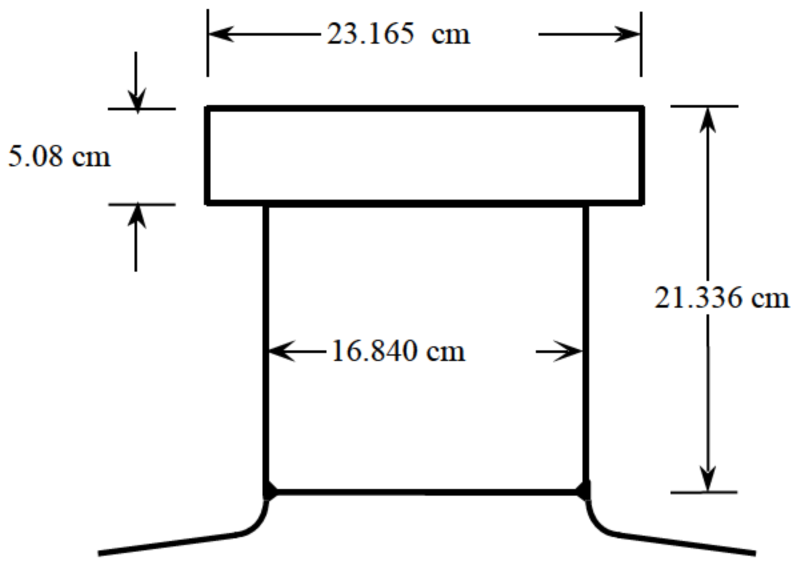
FIGURE 5.800.1 Tasks planned to satisfy Specification 3.13, Handling Features Specification.



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

FIGURE 5.800.2 Lifting Flange Geometry for DWPF Canisters (nominal dimensions shown).



PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

ITEM TITLE: 4. QUALITY ASSURANCE SPECIFICATION

4. QUALITY ASSURANCE SPECIFICATION

The Producer shall establish, maintain and execute a quality assurance (QA) program that applies to the testing and analysis activities that demonstrate compliance with these EM-WAPS during waste form qualification, production, acceptance, handling, storage, and preparation for shipment. The Producer shall impose a QA program consistent with the QA requirements that govern HLW as identified in the RW Quality Assurance Requirements and Description (QARD)[*] and the Civilian Radioactive Waste Management System's Waste Acceptance Systems Requirements Document (WA-SRD)[**].

Compliance Strategy

The DWPF will comply with the specification by developing a QA program which implements the requirements passed down by the Department of Energy's Office of Environmental Management line organization. Organizational interfaces and departmental responsibilities are implemented through procedures.

The Waste Form Compliance Plan will be used to determine which items and activities are included in the program. Since some of the data relevant to compliance with the WAPS were collected prior to imposition of controls by the Civilian Radioactive Waste Management System, an important part of the program is to identify methods for qualification of existing data. Given the likelihood of further changes in the quality assurance requirements, these same controls will be used to qualify data generated under previous quality assurance programs.

Implementation

The plan being followed to satisfy this specification is outlined in Figure 6.100.1. The plan includes the following elements:

- Preparation of the Waste Form Compliance Plan.
- Identification of items and activities which are important to compliance with the WAPS. These are called Waste Acceptance Process items and activities.
- Development and implementation of a Quality Assurance program which satisfies the specification.
- Preparation of the Waste Form Qualification Report.
- Development of a plan for qualification of data collected prior to initiation of the current QA program.
- Performance of a readiness review prior to radioactive waste form production.

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[*] U.S. Department of Energy, Office of Civilian Radioactive Waste Management, **Quality Assurance Requirements and Description of the Civilian Radioactive Waste Management Program**, U.S. DOE Document Number DOE/RW-0333P.

[**] U.S. Department of Energy, Office of Civilian Radioactive Waste Management, **Waste Acceptance System Requirements Document**, U.S. DOE Document Number DOE/RW-0351P.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.14 CONCENTRATION OF PLUTONIUM IN EACH CANISTER SPECIFICATION

3.14 CONCENTRATION OF PLUTONIUM IN EACH CANISTER SPECIFICATION

The concentration of plutonium in each HLW standard canister shall be less than 2,500 grams/cubic meter.

Compliance Strategy

The plutonium concentration limit specification requires the comparison of the canister's concentration of plutonium in grams per cubic meter to the International Atomic Energy Agency (IAEA) limit of 2,500 grams/cubic meter. The DWPF will determine the plutonium concentration in each DWPF canister as described in Part 3, Item 800. The comparison with 2,500 grams/cubic meter will validate that the DWPF canisters meet the IAEA requirement for plutonium content.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.850.1. Prior to satisfying specification 3.14, the tasks required to satisfy specification 1.6 (specifically, the reporting of the plutonium concentration per canister) must be completed (see Part 3, Item 800).

Determining the Total Plutonium Concentration Per Canister

Part 3, Item 800 provides a discussion of the methods that the DWPF uses to determine the plutonium content in grams/cubic meter.

Glass Sampling

At least one glass pour stream sample will be taken by DWPF during the processing of each sludge batch, analyzed as necessary and archived at the SRNL Shielded Cells Facility. These samples may be characterized should additional testing requirements be identified in the future but are no longer required for batch sampling confirmation.

Documentation

Volume 4 of the Waste Form Qualification Report will contain a discussion of the IAEA requirement limiting the total Pu concentration per canister to less than 2,500 grams/cubic meter.

The Production Record for each canistered waste form will include the following:

- total plutonium content per canister expressed as grams/m^3
- comparison with the IAEA limit of 2,500 grams/m^3

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

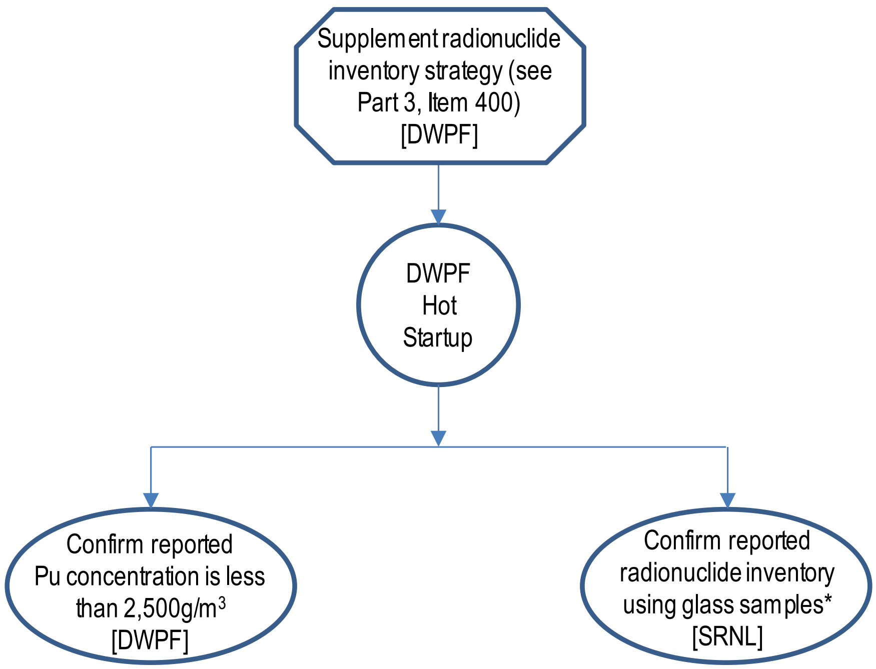
ITEM TITLE: 3.14 CONCENTRATION OF PLUTONIUM IN EACH CANISTER SPECIFICATION

The plutonium concentration used in the comparison will be reported as a single value for each canister in the entire macro-batch.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.14 CONCENTRATION OF PLUTONIUM IN EACH CANISTER SPECIFICATION

FIGURE 5.850.1 Tasks planned to satisfy Specification 3.14, Concentration of Plutonium in each Canister Specification.



*Beginning with Sludge Batch 9, glass samples will be archived at SRNL and only characterized upon request.

PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

ITEM TITLE: 4. QUALITY ASSURANCE SPECIFICATION

Preparation of the Waste Form Compliance Plan

The WCP is an essential first step for implementation of the Quality Assurance program related to waste form production. As the plan for compliance with the WAPS, it defines the scope to which the Quality Assurance program applies. The WCP has been prepared by the DWPF with the assistance of the Savannah River Technology Center (SRTC). The WCP is issued and maintained by the DWPF, and revised as necessary. The first version of the WCP was prepared in 1986, and has been updated periodically since that time. Since 1990, major revisions of the WCP have undergone independent technical review by DOE's Waste Acceptance Technical Review Group (TRG). This group, with joint sponsorship and participation by DOE's Offices of Civilian Radioactive Waste Management (RW), and Environmental Management, is responsible for independently assessing the technical adequacy of the WCP, and other Waste Acceptance Process documents.

Identification of Waste Acceptance Process Items and Activities

The purpose of identifying items and activities is to signify their importance to Waste Acceptance Process objectives, so that appropriate mechanisms can be established for their control. The DWPF has used the WCP to identify Waste Acceptance Process items and activities (i.e., to identify the scope of the QA program designed to meet the specification). Included in this set of items and activities are

- All activities described in the Waste Form Compliance Plan which are important for compliance with the WAPS.

- Other actions which directly support these Waste Acceptance Process activities, for example: the DWPF Startup Test Program, calibration of measuring and test equipment, control of procurement, and control of documents. All support activities which affect the ability of the canistered waste form to comply with the WAPS will be subject to this quality assurance program.

- All pieces of equipment, systems, and other items described in the WCP which are important for compliance with the WAPS.

- Other activities or items which support the use of Waste Acceptance Process items, for example: operating procedures for the Inner Canister Closure, operating procedures for the canister welder, training of personnel to use the Product Composition Control System.

The listing of Waste Acceptance Process items and activities is maintained in the Waste Acceptance Reference Manual[1].

Development of Quality Assurance Program

The Office of Civilian Radioactive Waste Management's (RW's) quality assurance requirements are imposed on the DWPF through the issuance of Contractor Administrator Notices (CANs) by DOE-SR. These CANs are intended to specify what quality assurance program/DOE Directive is to be implemented (i.e., the RW Quality Assurance Requirements and Description [QARD]/RW-0333P) along with the applicable revision. The requirements of the QA program along with DWPF's compliance with the requirements are illustrated in tables in the WSRC

PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

ITEM TITLE: 4. QUALITY ASSURANCE SPECIFICATION

Standards/Requirements Identification Document (S/RID), functional Area 2, Quality Assurance. The requirements that apply to the DWPF are baselined in Table 1 of the S/RID which is approved by DOE-SR. Compliance with the requirements is illustrated in Table 3-1 of the S/RID. Table 3-1 is approved by DOE-SR, initially through document review, with subsequent revisions being accepted through audits and surveillances.

All organizations providing support to DWPF in performance of Waste Acceptance Process activities (in particular, SRTC) have established quality assurance programs which conform with the requirements. DWPF is responsible for acceptance oversight of these programs to ensure the conformance of the supporting organizations.

The quality assurance program describes the actions and responsibilities for:

- Defining technical requirements.

- Planning programs to meet those requirements.

- Preparing procedures to implement the program plans.

- Assuring that activities have been performed according to prepared and approved plans and procedures.

- Reviewing results to ensure that technical requirements have been met.

- Initiating, approving, and documenting changes to plans, programs or procedures.

- Reviewing the quality assurance program itself, and evaluating its effectiveness.

Work performed under this quality assurance program is periodically reviewed by the line organization responsible for the activity. These reviews are augmented by periodic independent surveillances, audits, and other oversight activities. The quality assurance program recognizes that these independent oversight activities are merely supplements to the review of Waste Acceptance Process activities by the line organization, and cannot be used as a substitute for demonstrable control.

Implementing procedures have been developed, reviewed, and approved for carrying out this program. These are currently being utilized for activities supporting qualification of the DWPF canistered waste form, and the associated production processes.

Preparation of the Waste Form Qualification Report (WQR)

The WQR will be prepared by the DWPF with the assistance of the Savannah River Technology Center (SRTC). The WQR is reviewed and accepted by the DWPF, before issue. The WQR will include work performed by SRTC in support of facility and equipment design and the results of the Qualification Runs. The Qualification Runs will demonstrate the DWPF’s ability to comply with the WAPS. The WQR is reviewed by the Waste Acceptance Technical Review Group (TRG) and/or the Department of Energy in order to independently assess the

PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

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technical adequacy of the document and to ensure that the DWPF has demonstrated its ability to comply with the WAPS.

Qualification of Existing Data

Research and development in support of the DWPF began during the 1970's at the Savannah River Technology Center (formerly the Savannah River Laboratory). Some of the data relevant to compliance with the WAPS was generated in support of facility and equipment design. Facility and equipment design, much of the construction, and fabrication of some of the major equipment systems (e.g., the canister welder) were completed prior to the preparation and issue of the WAPS and the WCP. Prudent stewardship of public monies demands that this data not be discarded unnecessarily.

These data collection efforts were initiated under the quality assurance programs and accepted practices of the Department of Energy (and its predecessors) and the operating contractor. These quality assurance programs were developed and implemented in the early 1980's in response to DOE Order 5700.6A and its referenced American National Standard on Quality Assurance Program Requirements for Nuclear Facilities, ANSI/ASME N45.2. These requirements were further extended to the major subcontractors designing and constructing the DWPF, and to the suppliers of equipment and services involved in the design, fabrication, and installation of the process and equipment. These requirements were also applied to the work of the Savannah River operating contractor organization at the DWPF as they provided overview and operations support to the design, construction, and testing activities. In general, these research and development programs were subdivided and planned as subprograms and tasks assigned to a principal investigator.

During the early research and development work, the Savannah River Technology Center developed a quality assurance program to implement DOE Order 5700.6A and its referenced American National Standard on Quality Assurance Program Requirements for Nuclear Facilities ANSI/ASME NQA-1, as well as its predecessor standard ANSI/ASME N45.2. A comprehensive quality assurance plan was developed and issued for the site, and a set of site-wide implementing procedures were prepared, issued, and implemented on the work performed prior to work initiated under the WCP.

To avoid needless duplication of effort, DWPF will review all data relevant to compliance with the WAPS collected prior to the application of the current QA program, and determine which may be qualified for use. As part of the review, a plan for qualification of these data sets will be developed. The qualification methods identified in NUREG-1298[2] (determination of equivalent controls, use of corroborating data, use of confirmatory testing, peer review) to be used to qualify each existing data set will be documented. Any data which must be included in the WQR (i.e., essential to compliance with the WAPS) that was completed prior to implementation of the quality assurance program described here will be qualified in accordance with NUREG-1298.[2]

References

1. **DWPF Waste Acceptance Reference Manual**, Westinghouse Savannah River Company, WSRC-IM-93-45, Aiken, SC.

PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

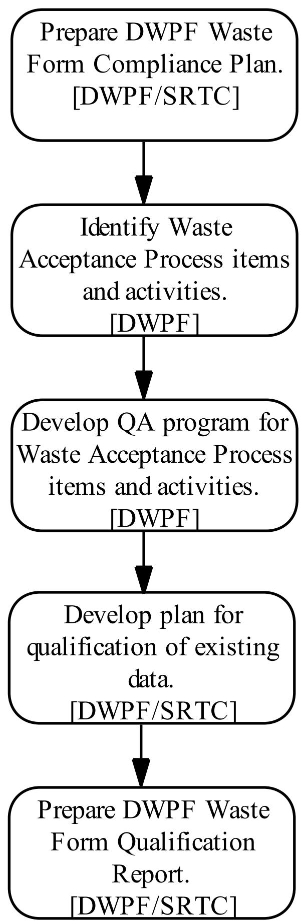
ITEM TITLE: 4. QUALITY ASSURANCE SPECIFICATION

2. U. S. Nuclear Regulatory Commission, **Qualification of Existing Data for High-Level Waste Repositories**, USNRC Document NUREG-1298, Washington, DC (1988).

PART TITLE: QUALITY ASSURANCE SPECIFICATIONS

ITEM TITLE: 4. QUALITY ASSURANCE SPECIFICATION

FIGURE 6.100.1 Tasks planned to satisfy Specification 4, Quality Assurance Specification.



PART TITLE: QUALITY ASSURANCE

ITEM TITLE: CHANGES RELATING TO WASTE ACCEPTANCE PROCESS ACTIVITIES

The Waste Form Compliance Plan (WCP) describes the actions and methods the DWPF will use to comply with the specifications. The WCP is used as the basis for the controlled list of items and activities important to compliance. Thus, the DWPF uses the WCP to identify necessary activities for management purposes (e.g., staffing, scheduling, and funding). However, the WCP is likely to be used for other purposes by other organizations within DOE. (For example, the Waste Acceptance System Requirements Document[1] indicates that OCRWM must be notified of proposed changes in the document, and given the chance to comment on those changes). The purpose of this item is to describe how the operating contractor for the DWPF will notify organizations within DOE of the need for change in the document, and of the actions it will take to gain approval of those changes.

Under certain circumstances, changes in the activities described in the Waste Form Compliance Plan may be desirable. These circumstances include, but are not limited to, the following:

- Unexpected results of performing a Waste Acceptance Process activity could indicate a need to significantly change the course of the subsequent actions.

- Changes in the DWPF process could require different, or additional, Waste Acceptance Process activities.

- Improved technology, not foreseen when the WCP was formulated, could significantly enhance the quality of Waste Acceptance Process activities.

To allow such beneficial changes, the following procedure will be followed. This procedure will take effect as soon as DOE-SR concurs with the DWPF Waste Form Compliance Plan.

1. DWPF will identify a need for a change in the Waste Acceptance Process activities identified in the Waste Form Compliance Plan, and notify DOE-SR of this need, in writing. Within the DWPF, this identification and documentation of the need for a change will be processed in accordance with the DWPF Quality Assurance Program.

2. DWPF will develop a justification for the proposed change. This justification will describe the proposed change, the reasons for making the change and the expected impact of the change on other Waste Acceptance Process activities.

3. DWPF will transmit the proposed change and its justification to DOE-SR, for review and comment. DOE-SR will be responsible for transmittal of the proposed change and its justification to any other affected organizations, and for transmitting comments back to DWPF.

4. DWPF will disposition any comments received, and transmit the disposition to the DOE-SR for approval.

5. After approval is received from DOE-SR, DWPF will implement the change, and maintain the WCP as a controlled document in accordance with the DWPF Quality Assurance Program.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: CHANGES RELATING TO WASTE ACCEPTANCE PROCESS ACTIVITIES

References

1. Office of Civilian Radioactive Waste Management, **Waste Acceptance System Requirements Document**, USDOE Document RW-0351P.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: DISPOSITION OF NONCONFORMING CANISTERED WASTE FORMS

4. QUALITY ASSURANCE SPECIFICATION

The Producer shall submit an action plan, signed by authorized personnel, through EM to DOE-RW for correction or disposition of nonconforming waste forms for verification and documented approval from RW. The action plan must identify and describe the nonconformance and any action to change or correct the existing nonconformance.

Implementation

As is recognized in the Introduction to the WAPS, and in Part 1, Item 200 of this document, some individual canistered waste forms may not comply in every respect with the specifications. Within the DWPF, these nonconformances to the WAPS will be identified, and documented, in accordance with the DWPF Quality Assurance Program. However, disposition of a WAPS nonconformance by the DWPF without the knowledge or concurrence of other affected organizations within DOE may inadvertently compromise either the shipment or the disposal of the nonconforming canistered waste form. The purpose of this item is to describe how the operating contractor for the DWPF will notify organizations within DOE of the existence of a nonconformance, and of any the actions it will take to gain approval of proposed dispositions.

The following procedure will be used. This procedure is intended to allow expeditious and consistent disposition of these items.

1. The DWPF will identify the nonconforming canistered waste form, and notify DOE-SR, in writing, of the possible existence of a nonconforming canistered waste form, its identification, and the specifications with which it may not comply.

2. DOE-SR will notify the appropriate offices in DOE.

3. DWPF will prepare an action plan containing the following information: the WAPS requirement violated, the Nonconformance Report (NCR) number, a description of the nonconformance, the recommended or proposed disposition of the NCR and the actions to be taken.

4. DWPF will transmit the action plan to DOE-SR, for review and comment. DOE-SR will be responsible for transmittal of the proposed disposition plan to other affected DOE offices including DOE-EM and DOE-RW.

5. DWPF will revise the action plan, in response to any comments received.

6. After approval is received from DOE-SR, DOE-EM and DOE-RW, DWPF will proceed to carry out the action plan.

7. DWPF will certify compliance with the action plan in an addendum to the Production Record (or Storage and Shipping Record) for the nonconforming canistered waste form. The nonconforming canistered waste form and its Production Record will then be processed by the procedures established for disposal of conforming waste forms, as amended by the approved action plan.

CONTENTS OF DWPF WASTE FORM QUALIFICATION REPORT

DWPF Waste Form Qualification Report

Volume 1: Chemical Composition Projections for the DWPF Product
WAPS 1.1.1 Chemical Composition Projections

Volume 2: Reporting the Chemical Composition of the DWPF Product
WAPS 1.1.2 Chemical Composition During Production

Volume 3: Projected Radionuclide Inventories and Radiogenic Properties of the DWPF Product
WAPS 1.2.1 Radionuclide Inventory Projections
WAPS 3.8.1 Heat Generation Projections
WAPS 3.9.1 Projections of Dose Rates
WAPS 3.10 Subcriticality Specification

Volume 4: Radionuclide Inventory During Production
WAPS 1.2.2 Radionuclide Inventory During Production
WAPS 1.6 International Atomic Energy Agency (IAEA) Safeguards Reporting for HLW Specification
WAPS 3.14 Concentration of Plutonium in Each Canister Specification

Volume 5: Technical Bases for Glass Product Control Program
WAPS 1.3 Specification for Product Consistency

Volume 6: DWPF Glass Product Control Program
WAPS 1.3 Specification for Product Consistency

Volume 7: Phase Stability and Control of the Temperature of the DWPF Product
WAPS 1.4 Specification for Phase Stability

Volume 8: DWPF Canister Procurement, Control, Drop Test, and Closure
WAPS 2.1 Material Specification
WAPS 2.2 Fabrication and Closure Specification
WAPS 2.3 Identification and Labeling Specification
WAPS 2.4 Specification for Canister Length and Diameter
WAPS 3.11 Specification for Weight and Overall Dimensions
WAPS 3.12 Drop Test Specification
WAPS 3.13 Handling Features Specification

Volume 9: Exclusion of Foreign Materials and Prevention of Internal Corrosion of DWPF Canistered Waste Forms
WAPS 3.1 Free Liquid Specification
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Volume 10: Controlling the Glass Fill Height of the DWPF Product
WAPS 3.6 Fill Height Specification

Volume 11: Control of Surface Contamination
WAPS 3.7 Specification for Removable Radioactive Contamination on External Surfaces

Volume 12: Reporting Dose and Heat Generation Rates of the DWPF Product
WAPS 3.8.2 Heat Generation at Year of Shipment
WAPS 3.9.2 Dose Rates at Time of Shipment

Volume 13 Hazardous Waste Determination of the DWPF Product
WAPS 1.5 Hazardous Waste Specification

DESCRIPTION

OF THE PRODUCTION RECORDS FOR

DWPF CANISTERED WASTE FORMS

APPENDIX 1.200.1 Description of the DWPF Production Records

INTRODUCTION

The Department of Energy's Office of Environmental Management (EM) has established specifications the DWPF product must meet. These Waste Acceptance Product Specifications (WAPS) require that the DWPF provide evidence of compliance with the WAPS during production. This evidence is to be documented and sent to the Office of Civilian Radioactive Waste Management (RW) in the form of Production Records for DWPF canistered waste forms. In this Appendix, the content of the Production Records is detailed, based on the WAPS and the Waste Acceptance Process activities described in the DWPF Waste Form Compliance Plan. Other quality assurance records, such as training records and audit reports, will be collected, maintained, and dispositioned in accordance with DWPF implementing procedures developed under the Quality Assurance Program described in Part 6, Item 100.

CONTENT

The Production Records summarize the detailed records of DWPF canistered waste form production. The Production Record will provide references to these detailed records (primarily through canister and batch identifications) so that more detailed information can be retrieved, if necessary. The information provided in the Production Records will demonstrate that each DWPF canistered waste form complies with the specifications. The program to gather this information will be tested during Waste Qualification Runs. Other records generated during production that contain information on the characteristics of the canistered waste form may be included in the Production Records as determined by the Waste Acceptance Technical Review Group and approved by the DOE-Headquarters DWPF Program Manager. It is anticipated that the Waste Qualification Runs will provide an opportunity for the Waste Acceptance Technical Review Group to identify additional data as candidates for inclusion in the Production Records. If the need for further Production Records is identified following Waste Qualification Runs, the WCP and the DWPF programs will be revised. The DWPF will provide the Production Records to RW in accordance with the Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste between the Assistant Secretary for EM and the RW Director.[1] The information to be reported is summarized in Table 1.200.1.1. Any actions to be taken based on the information are identified below.

Macro-batches

The "macro-batch" is a key concept for compliance with the Chemical Composition During Production Specification (1.1.2), the Radionuclide Inventory During Production Specification (1.2.2), the Product Consistency Specification (1.3) and the IAEA Reporting Specification (1.6). The feed to the DWPF will remain relatively constant for extended periods of time. The sludge will be prepared in 200,000 to 1,000,000 gallon batches. The salt effluent feed will also be prepared in similar batches. The periods of relatively constant feed constitute macro-batches, which the DWPF will treat as the "waste types" referred to in the above mentioned specifications.

Identification and Labeling

The Production Records will identify particular canisters by the code on the label affixed to them. This code, unique to each canister, will be the key to tracing the records for each canistered waste form. All of the records which support the information reported in the Production Records will be keyed to that code.

Timing

The DWPF will provide the original Production Records (or copies in accordance with requirements for QA records packages) to RW at the time of acceptance of the canistered waste forms.[1] Copies of the Production Records will be made available for RW review and approval at least 12 months prior to the scheduled acceptance. RW should review the Production Records for completeness and accuracy in accordance with appropriate QA requirements. The Production Records will be treated as lifetime quality records by the DWPF.

Use of Glass Sample(s)

During each sludge batch at least one sample of production glass will be taken from the Melt Cell (see Part 3, Items 200, 400, 500 and 800 and Part 5, Item 850) and sent to SRNL to be archived in the SRNL Shielded Cells Facility. If requested SRNL will provide characterization of the archived samples and will report these results to the DWPF as summary reports, keyed to the number of the canister being filled during sampling. DWPF will accept each SRNL summary report with a memorandum, and both documents will be included in the Production Record for the canistered waste form, where applicable.

Chemical Composition During Production (WAPS 1.1.2)

The WAPS require that the DWPF report the content of all elements, excluding oxygen, which are present in concentrations greater than 0.5 wt% of the glass, expressed as oxides. This information will be calculated from analyses of samples from each process batch.

The individual elemental analyses for the macro-batch will be determined by analyses of each process batch in the SME. The values to be reported in the Production Records will be the numerical average and standard deviation calculated from these analyses for an entire macro-batch, expressed as oxides. Thus, the reported chemical composition will be the same for all canisters produced from a given macro-batch of feed. In addition, the results of performing chemical analyses on production sample(s) of glass will also be reported, where applicable.

For compliance with WAPS 1.1.2, the Production Records will contain the following information:

- The canister number.

- The macro-batch number.

- The process batch number(s).

- Each major (present at greater than 0.5 wt%) element, expressed as its oxide, and the content of the oxide, the calculated standard deviation for the analysis, and the number of analyses performed for a given macro-batch of feed. Each major (present at greater than 0.5 wt%) element, expressed as its oxide, and the content of the oxide for the production glass sample(s) taken for a given macro-batch, where applicable.

Radionuclide Inventory During Production and International Atomic Energy Agency (IAEA) Safeguards Reporting (WAPS 1.2.2, 1.6 and 3.14)

The WAPS require that the DWPF report estimates of the inventory of all radionuclides with half-lives greater than 10 years, and present in the glass at greater than 0.05% of the total radionuclide inventory indexed to the years 2015 and 3115. NOTE: For macrobatches analyzed after 2015, the initial index year will be the year of radionuclide analysis (e.g., 2017) and the final index year will continue as 3115(see WQR Volume 4). Decay calculations will be made for 2115, 2215, 2315 and every 100 years up to the final index year of 3115. Additionally, the WAPS require that the DWPF report the uranium and plutonium content of each canister and verify that the plutonium concentration is less than 2,500 grams/cubic meter. This information will be calculated from analyses of samples from each process batch in the SME and analyses of Tank Farm samples of DWPF feed. In addition, the results of performing radiochemical analyses on production samples of glass will also be reported, where applicable.

The values to be reported in the Production Records will depend on the particular radionuclide (see Part 3, Items 400 and 800). For all radionuclides, the reported inventory is the same for all canisters in the macro-batch.

For compliance with WAPS 1.2.2, 1.6 and 3.14, the Production Records will contain the following information:

- The canister number.

- The macro-batch number.

- The process batch number(s).

- Each reportable radionuclide, and its calculated content for a given macro-batch of feed.

- The total uranium and plutonium content per canister and the mass ratios of the required uranium and plutonium isotopes.

- The total plutonium content per canister expressed as grams/m^3 and comparison with the IAEA limit of 2,500 grams/m^3.

The results of performing radionuclide analysis on the production glass sample(s) for a given macro-batch, where applicable.

Aside from the plutonium concentration limit (WAPS 3.14), there are no specific limits on the radionuclide inventory itself. However, as discussed below, the values will be used to calculate the heat generation rate, which has a specified limit. Thus, the limit on heat generation rate constitutes an implied limit on the allowed radionuclide inventory.

Product Consistency (WAPS 1.3)

The DWPF will report the average of the PCT projections (normalized lithium, sodium and boron concentrations) for each process batch in the macro-batch. This will include the standard deviation of the prediction. The DWPF will also report the normalized boron, lithium and sodium concentrations on the PCT predicted from the average composition of each macro-batch (see Production Records for compliance with WAPS 1.1.2). Thus, the predicted PCT results will be the same for every canistered waste form in the macro-batch. The DWPF will also certify that these values are at least two standard deviations below the mean of the PCT results for the benchmark glass of specification 1.3. The PCT projections for the individual process batches will also be reported to verify that each process batch has been controlled to comply with specification 1.3. In addition, the results of performing the PCT on production sample(s) of glass will also be reported, where applicable, to confirm that the DWPF-produced glass is more durable than the Environmental Assessment (EA) glass.

For compliance with WAPS 1.3 the Production Records will contain the following information:

- The average and standard deviation of the normalized concentrations of boron, lithium and sodium predicted by the PCCS for each macro-batch. The PCT projections for each process batch in the macro-batch will also be included.

- The normalized concentrations of lithium, sodium and boron, predicted from the chemical composition of the macro-batch.

The results of performing the PCT on actual production glass sample(s) for a given macro-batch, where applicable.

Hazardous Waste (WAPS 1.5)

The WAPS require that the Producer report and certify in the WQR that the waste is not hazardous, including the absence of any listed components.

Canister Material, Fabrication and Closure, and Dimensions (WAPS 2.1, 2.2, 2.4, and 3.11)

The WAPS require that the DWPF document in the Production Records the compliance with the materials specification, certify that the closed canister is leaktight, and report the unfilled canister diameter, length, and wall thickness. The Production Records will reference the procurement documents for the canister. Procurement documents will include specifications, purchase orders, vendor and heat identification, certificates of analyses, diameter, length, wall thickness measurements, radiography test reports, and inspection records.

The Production Records will summarize the welding parameters measured by the canister welder's data acquisition system. If these values are outside the range of parameters which have been shown to produce a leaktight weld (Part 4, Item 200), a flag is set which identifies the canister weld as a nonconforming item, which is dispositioned as described in Part 6, Item 300 of the WCP. If a repair weld is applied, the Production Records will summarize the welding parameters associated with application of that weld.

For compliance with WAPS 2.1, 2.2, 2.4, and partial compliance with WAPS 3.11, the Production Records will contain the following information:

- Canister number.
- Tapered plug number, repair plug number, and weld plug number.
- Supplier name(s).
- Order number(s).
- Certification of compliance with materials specification.
- Diameter length and wall thickness measurements of the unfilled canister.
- The maximum force and current applied during closure of the canister in the DWPF and the duration of application of the force and current.

<u>Canister Content Controls (WAPS 3.1, 3.2, 3.3, 3.4, 3.5)</u>

The WAPS has no documentation requirements for exclusion of foreign materials (those excluded by specifications 3.1 to 3.4). However, because of the importance of the Inner Canister Closure in meeting this specification, its leak rate will be reported.

For compliance with WAPS 3.1, 3.2, 3.3, 3.4, and 3.5, the Production Records will contain the following information:

- Canister number.
- Tapered plug number.
- Supplier name(s).

- Order number(s).

- Certification that all in-process inspections were performed to ensure the exclusion of foreign materials.

- Leak rate of the inner canister closure (ICC).

- Identification of an ICC as a repair ICC, and the parameters associated with it (e.g., leak rate, repair plug number).

Canister Fill Level (WAPS 3.6)

The WAPS require that the DWPF report, in the Production Records, the fill level within each canister. This information will be obtained from the infrared level detection system.

The Production Records for each canister which has less than 80% fill height will clearly indicate this, but the DWPF proposes to take no further action (i.e., attempting to perform another pour into the canister) if the 80% fill height is not achieved.

The form for this record contains:

- The canister number.

- The glass height determined from the infrared level detection system.

- The date the canister was filled.

References

1. U.S. Department of Energy Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste, between the Assistant Secretary for Environmental Management (EM), and the Director, Office of Civilian Radioactive Waste Management (RW), Washington, D.C.

2. J. W. Ray, "Defense Waste Processing Facility (DWPF) Path Forward on DOE-EM Waste Acceptance Product Specifications (WAPS) 2015 Index Year for Radionuclide Reporting," SRR-WSE-2018-00020, Revision 0, Savannah River Site, Aiken, SC (2018).

TABLE 1.200.1.1 Content of DWPF Production Records

Specification	Information in the Production Records
1.1.2	Elemental composition of glass produced from a macro-batch of feed (For all elements > 0.5 wt% of glass)
1.2.2	Estimates of radionuclide inventory of glass produced from a macro-batch of feed (For all radionuclides with $\tau_{1/2}$ > 10 yr and > 0.01% of Ci for times between 0 and 1100 years)
1.3	Average of the predicted PCT results for each process batch in a given macro-batch (the PCT predictions for each process batch will also be included). The PCT results predicted from the chemical composition of the macro-batch. Results of Product Consistency Test from production glass sample(s) and a comparison to EA glass PCT results, where applicable.
1.5	Statement that the DWPF glass waste form is non-hazardous as documented in Volume 13 of the WQR
1.6	Total uranium and plutonium content and weight ratios of uranium and plutonium isotopes for glass produced from a macro-batch
2.1	Reference to canister procurement documents, supplier name and purchase order number
2.2	Closure weld parameters (force, time, current) and tapered plug/repair plug/weld plug number, supplier and purchase order number
2.3	Identification of canister
2.4	Canister length and diameter
3.1, 3.2, 3.3, 3.4, 3.5	Leak test result on Inner Canister Closure, certification that all appropriate inspections performed, plug number and supplier (including purchase order number)
3.6	Glass fill level from infrared level detection system and date canister was filled
3.11	Wall thickness of canister
3.14	Plutonium concentration limit of 2500 g/m^3 per canister

DESCRIPTION

OF THE STORAGE AND SHIPPING RECORDS FOR

DWPF CANISTERED WASTE FORMS

APPENDIX 1.200.2 Description of the DWPF Storage and Shipping Records

INTRODUCTION

The Department of Energy's Office of Environmental Management (EM) has established specifications the DWPF product must meet. These Waste Acceptance Product Specifications (WAPS) require that the DWPF provide evidence of compliance with the WAPS during production. This evidence is to be documented and sent to the Office of Civilian Radioactive Waste Management (RW) in the form of Storage and Shipping Records for DWPF canistered waste forms. In this Appendix the content of the Storage and Shipping Records is detailed, based on the WAPS and the Waste Acceptance Process activities described in the DWPF Waste Form Compliance Plan.

CONTENT

The Storage and Shipping Records summarize the storage history of DWPF canistered waste form after production and contain information necessary for shipment. The DWPF will provide the Storage and Shipping Records to the Office of Civilian Radioactive Waste Management at time of shipment of the canistered waste forms. Because it is unlikely that this will occur before the year 2015, a shipping facility to accomplish many of the actions described in this Appendix has not yet been designed. Such a facility will undoubtedly contain a smear test station, equipment to measure the weight and dimensions of canistered waste forms, instruments to measure the dose rate from the canistered waste form, and other equipment necessary to satisfy whatever specifications are in existence at that time.

The information to be reported is summarized in Table 1.200.2.1. Any actions to be taken based on the information are also identified.

Identification and Labeling

The Storage and Shipping Records will identify particular canisters by the code on the label affixed to the canister. This code, unique to each canister, will be the key to tracing the records for each canistered waste form.

Timing

The DWPF will provide the original Storage and Shipping Records (or copies in accordance with requirements for QA records packages) to RW at the time of acceptance of the canistered waste forms.[1] Copies of the Storage and Shipping Records will be made available for RW review and approval at least 12 months prior to the scheduled acceptance. RW should review the Storage and Shipping Records for completeness and accuracy in accordance with appropriate QA requirements. The Storage and Shipping Records will be treated by the DWPF as lifetime quality records.

Phase Stability

The Storage and Shipping Record for each canistered waste form will certify that the maximum waste glass temperature experienced during storage of each canistered waste form is at least 100°C below the transition temperature. The Storage and Shipping Record for each canistered waste form will also certify that after initial cooldown, no unusual events occurred which would cause the maximum temperature of the canistered waste form to exceed the specified temperature (400°C), during handling and storage at the DWPF. After filling, the canister will be held in the Melt Cell until it cools below 100°C (thus, unless some thermal excursion occurs, the canister temperature must be less than 100°C at time of shipment). After the canister is transferred to the Canister Decontamination Cell, it can exceed the specified temperature (400°C) in only two ways:

- The heat generation rate of the glass is too high, so that heat buildup occurs during storage. The heat generation rate of the glass will be calculated from the radionuclide inventory (see below). Calculations using the design of the interim Glass Waste Storage Buildings (GWSBs) and the projected heat generation rates will be used to show that the specified temperature (400°C) will not be exceeded. Although detailed calculations have not yet been performed, they are expected to show that canisters of waste glass which comply with the heat generation rate specification also comply with this specification. These detailed calculations will be included in the Waste Form Qualification Report.

- An unexpected high temperature event, such as a fire in the interim GWSBs, has exposed the glass to high temperatures. Temperature sensing devices in the GWSBs may be used to evaluate the impact of such an event on the canistered waste forms stored in the GWSBs. If the sensors are damaged/inoperable or the temperature excursion data are not available, other means, such as calculations will be used to assess the impact on the temperature of the glass.

If a high temperature is detected in the GWSBs or a high temperature is calculated, a written record will be generated which includes:

- Date(s) and duration of excursion.

- The maximum temperature reached.

- The canisters contained in the GWSBs during the excursion.

- A statement that these canisters are potentially nonconforming items.

This record will be included in the Storage and Shipping Records.

If such a condition occurs, an investigation of the incident will be documented, and the canisters will be dispositioned as described in Part 6, Item 300 of the WCP. The disposition will also be included in the Storage and Shipping Records.

Removal of Canister Contamination

The WAPS require that the DWPF provide evidence of removal of contamination in the Storage and Shipping Records. The DWPF will report the smear test results for each canister. If the level of contamination exceeds 2,200 alpha dpm/100 cm^2, or 22,000 beta or gamma dpm/100 cm^2, the canister will be decontaminated again before it is placed in the cask. In this case, the results of a confirmatory smear test will also be reported.

If the canister contamination level cannot be brought down to the DOE specified values discussed above, then the canister will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300 of the Waste Form Compliance Plan.

The record will include the results of smear tests from the shipping facility, and identification of tester(s).

Heat Generation Rate

The WAPS require that the DWPF report, in the Storage and Shipping Records, the heat generation rate for the canistered waste forms at year of shipment. The heat generation rate will be calculated from the radionuclide content of the glass shortly before shipment of the canistered waste forms, using standard values[2] of the thermal output per unit activity for each radionuclide. The radionuclides which will be included in performing this calculation will be those which significantly contribute to the heat generation. The radionuclides to be reported to the repository as part of the radionuclide inventory, as well as radionuclides analyzed for process control purposes in the DWPF will be considered.

Gamma and Neutron Dose Rates

The WAPS require that the DWPF report, in the Storage and Shipping Records, the gamma and neutron dose rates for the canistered waste forms, at time of shipment. At time of shipment, these will be measured in the DWPF shipping facility.

If the measured dose rates exceed 10^5 rem/hr surface gamma dose rate, or 10 rem/hr neutron dose rate, then the canister will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300 of the Waste Form Compliance Plan.

Weight and Overall Dimensions

The WAPS require that the DWPF report the weight of each glass-filled canister in the Storage and Shipping Records. The DWPF must also certify that the canister will fit without forcing into a right circular cylinder. The weight will be measured prior to shipment, and the weight and the estimated error of the measurement reported. Methods to certify the canister will fit without forcing into a cask have not yet been developed but will probably involve use of a ring gauge.

If the canister weight exceeds the specified amount or the canister cannot fit in the specified cylinder, then the canistered waste form will be identified as a nonconforming item, and dispositioned according to the procedure outlined in Part 6, Item 300 of the Waste Form Compliance Plan.

References

1. **U.S. Department of Energy Memorandum of Agreement for Acceptance of Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste,** between the Assistant Secretary for Environmental Management (EM), and the Director, Office of Civilian Radioactive Waste Management (RW), Washington, D.C.

2. **Integrated Data Base for 1990: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics**, USDOE Report RW-0006, Revision 6.

TABLE 1.200.2.1 Content of DWPF Storage and Shipping Records

Specification	Information in the Storage and Shipping Records
1.4	Certification that the maximum waste form temperature has always been below 400°C
3.7	Results of smear tests performed in the shipping facility
3.8.2	Heat generation rate
3.9.2	Gamma and neutron dose rates
3.11	Weight of filled canister, and estimated error
3.11	Certify that canister fits without forcing into the specified cylinder

SUMMARY

DWPF QUALIFICATION RUNS ACTIVITIES

APPENDIX 1.200.3 Summary of DWPF Qualification Runs Activities Relevant to the Waste Acceptance Process

OBJECTIVES

The objectives of the DWPF Startup Test Program are to accomplish the following:

- To demonstrate the overall functionality of the DWPF process and its auxiliary facilities using synthetic feeds so that operating conditions and procedural requirements can be adequately demonstrated prior to beginning radioactive operations.

- To perform tests required by the Waste Form Compliance Plan (WCP) which demonstrate that the DWPF process and product control are adequate to satisfy the requirements of the Waste Acceptance Product Specifications (WAPS).

A major portion of the Startup Test Program deals with production of simulated canistered waste forms in prototypic manner, to demonstrate, in particular, control of the vitrification process. The campaigns in the facility during which this will be accomplished are called the Qualification Runs. The activities which will be performed as part of the Qualification Runs are described in the Appendix. This appendix does not address those tests that will be performed during initial Radioactive Operations (e.g., reporting of radionuclide inventory and smear testing). These tests are discussed in the specific sections of the Waste Form Compliance Plan. The results of all testing will be reported in the Waste Form Qualification Report.

QUALIFICATION RUNS

The sections below describe specific tests which will be performed during the Startup Test Program for inclusion in the Waste Form Qualification Report to demonstrate compliance with the WAPS. In addition, most of the routine measurements and procedures which will be performed during radioactive operations and included in the Production Records will also be performed during this time.

The initial charge to the melter will be glass frit specially formulated for melter startup. After building the melter level to the operating level and achieving stable melter operation, the Qualification Runs will begin. These campaigns will be sludge/precipitate runs with (in order of performance):

a) a nonradioactive doped composition to simulate variations around the composite feed (approximately 7 canisters containing 26,000 lbs of glass produced, corresponding to almost 2 melter turnovers),

b) a nonradioactive low viscosity (high iron) composition to simulate another extreme change in feed composition (approximately 20 canisters containing 75,000 pounds of glass produced, corresponding to 5 melter turnovers), and

c) a nonradioactive high viscosity (high aluminum) composition to simulate an extreme change in feed composition (approximately 20 canisters containing 75,000 pounds of glass produced, corresponding to 5 melter turnovers),

d) a nonradioactive composite feed to simulate return to standard operation from high viscosity (approximately 10 canisters containing 37,000 pounds of glass produced, corresponding to 2.5 melter turnovers).

To obtain glass samples for characterization, approximately twenty-one glass filled canisters (three from the beginning and three from the end of each campaign, except WP-17 which will have three from the beginning only) will be sliced into 4 horizontal sections using a band saw. One of the slices will be made at the approximate height corresponding to the level of the glass in the canister when the glass pour stream sample was taken. The remaining glass filled canisters will have a 12” wide section of the canister wall removed using arc-air cutting.

<u>Chemical Composition Projections (Specification 1.1.1)</u>

Cooldown profiles for the canisters obtained during pilot-scale testing will be verified during Qualification Runs under typical production conditions. Special instrumented canisters will be designed and procured to perform these tests. The temperature profiles will then be combined with expected heat generation from radioactive decay to demonstrate that the glass product will comply with the WAPS.

There are no specific acceptance requirements for this testing; however, the objective discussed above must be met.

<u>Chemical Composition During Production (Specification 1.1.2)</u>

The DWPF will demonstrate, during Qualification Runs, its strategy for reporting the chemical composition. This will be accomplished by the following objectives:

- Confirm the compliance strategy for predicting the glass product composition from the macro-batch chemical composition based on process batch analyses. Compare the chemical composition of Slurry Mix Evaporator (SME) samples and Melter Feed Tank (MFT) samples to the glass samples taken from sectioned canisters, those with the wall removed, and those taken from the pour stream.

- Provide an estimate of the error of the composition.

- Determine crystalline content (type and amount), if any, in the glass samples taken from the canisters.

There are no specific acceptance requirements for this testing; however, the above objectives must be met

<u>Product Consistency (Specification 1.3)</u>

The DWPF must demonstrate that it can consistently produce a glass product that meets the Product Consistency Specification, WAPS 1.3. This will involve operating the melter with a range of feed compositions with various rheological properties (as discussed earlier) and using the Glass Product Control Program (GPCP) to control the glass composition. The GPCP states that no material can be transferred from the Slurry Mix Evaporator to the Melter Feed Tank until it is determined to be acceptable (see Part 3, Item 500). As discussed earlier glass samples will be taken from sectioned and wall removal canisters for analysis. The demonstration of product consistency includes the following objectives:

- Demonstrate that DWPF can obtain glass pour stream samples during Qualification Runs.

- Verify that the glass pour stream sample is representative of canister contents. The objective is to show that both the chemical composition results and the PCT results are the same within the applicable uncertainty.

- Verify canister glass homogeneity by demonstrating that the results of the analyses of glass samples taken from the canisters do not indicate that the position of the glass sample is a significant source of variance.

- Demonstrate the effectiveness of the Glass Product Control Program by verifying that the PCT results (Na, Li, B) of all the glass samples analyzed are at least 2 standard deviations below the mean PCT results of the EA glass (compliance with WAPS 1.3). The acceptability of each individual glass sample will be determined using the standard deviation of the PCT for that glass sample. The acceptability of the collection of glass samples from each melter run will be determined using a standard deviation that includes all sources of composition and PCT variation.

- Compare predicted Product Consistency Test results from the Product Composition Control System (PCCS) to actual PCT results from the glass samples taken from the last three sectioned canisters for first three melter campaigns to validate the Product Composition Control System’s ability to determine the acceptability of melter feed material. The objective is to show that the mean predicted PCT results from the PCCS and the mean results for actual glass samples from the sectioned canisters, over each melter run, are not different at the 5% significance level.

- Confirm the compliance strategy and determine the error for reporting the glass PCT results from the predicted PCT results from each process batch over the macro-batch. For each melter run, compare the predicted PCT results of Slurry Mix Evaporator (SME) samples to the PCT results of the glass samples taken from sectioned canisters, those with the wall removed, and those taken from the pour stream. The goal of this comparison is to show that the results are within 30% of each other. A goal of 30% was set for Qualification Runs because the DWPF will only be processing a few process batches (3-5) during each melter run. Thus, this difference is much larger than expected during Radioactive Operations. A secondary objective is to try to establish the mixing behavior of the melter.

The only specific acceptance requirement for this testing is that the PCT results (Na, Li, B) of all the glass samples analyzed be at least 2 standard deviations below the mean PCT results of the EA glass (compliance with WAPS 1.3). In addition, all of the above objectives must be met.

<u>Chemical and Phase Stability (Specification 1.4)</u>

Calculations will be performed to determine if the canistered waste form can ever exceed 400°C even under upset conditions. The Glass Waste Storage

Buildings also contain temperature sensing devices, which may be used to evaluate the impact of an unexpected high temperature event on the canistered waste forms in the GWSBs.

Fabrication and Closure (specification 2.2)

The DWPF must demonstrate that it can produce acceptable welds (leaktight to 1 x 10^{-4} atm-cc/sec helium). The quality of the welds produced will also be verified by metallurgical characterization and physical testing. The objectives for this demonstration are as follows:

- Demonstrate that controls and procedures to be used during Radioactive Operations are adequate for producing acceptable welds.

- Confirm the acceptability of the alumina ceramic rings for the weld plug that are to be used during Radioactive Operations.

The acceptance requirement for this testing is that all welds tested must be leaktight to 1 x 10^{-4} atm-cc/sec helium.

Exclusion of Foreign Materials (Specifications 3.1, 3.2, 3.3, and 3.4)

The DWPF must demonstrate the controls used to exclude foreign materials from the canisters throughout the process. In particular, the DWPF must demonstrate the effectiveness of the Inner Canister Closure (ICC) plug for excluding foreign materials (especially water during decontamination). The ICCs must be leaktight such that the leak rate for helium gas does not exceed 2 x 10^{-4} atm-cc/sec prior to decontamination. DWPF must also demonstrate that the pressure within the welded canistered waste forms will be below 22 psia after cooling. The objectives for this demonstration are as follows:

- Demonstrate that the leak rates of several canisters have not degraded (within experimental error) after decontamination.

- Determine and evaluate any imprecision or bias associated with the DWPF leak rate measurement.

- Demonstrate the effectiveness of the DWPF controls (in particular the ICC) to exclude free liquid by demonstrating that no free liquid is present within the canister after glass filling and completion of canister processing.

- Determine the composition of the gas in the canister after glass filling and final closure to demonstrate no foreign materials are present in order to demonstrate the effectiveness of the DWPF controls to exclude foreign materials. Also report the detection limits of the instrument.

- Measure the internal gas pressure in the canister after glass filling and final closure to confirm that it is less than 22 psia at 25°C.

The acceptance requirements for this testing are:

- the inner canister closures must be leaktight to 2 x 10^{-4} atm-cc/sec prior to decontamination

- the internal pressure of the canistered waste forms tested must be less than 22 psia at 25°C

- dewpoint measurements and mass spectrometric data must indicate no detectable foreign materials

<u>Fill Height (Specification 3.6)</u>

Confirmation of an operable level detection system is required to demonstrate control of the fill level in the canister (desired minimum fill is the height corresponding to 80% of the free volume of the canister). The objectives for compliance with this specification are as follows:

- Demonstrate that the canister fill height can be monitored and controlled using the infrared level detection system.

The acceptance requirement for this testing is that the glass fill level can be monitored so that the canister can be filled to a height equivalent to at least 80% (by volume).

<u>Canister Decontamination (Specification 3.7)</u>

The DWPF must specify in the Storage and Shipping Records that external radioactive contamination on the canistered waste forms is below the limits specified by the WAPS. The method of decontamination of the canistered waste forms must be demonstrated during the Qualification Runs. This will be accomplished as follows:

- Visually examine selected canisters and evaluate whether the heat tint has been removed.

- Demonstrate remote glass removal by ensuring that the needle gun can reach the outside surface of the canister except the bottom. There is no identified method for glass adhesion to the canister bottom.

- Evaluate canister damage using the needle gun. The needle gun should not cause gouges or dents that are greater the 1/32” deep.

There are no specific acceptance requirements for this testing; however, the above objectives must be met.

<u>Canister Dimensions (Specifications 2.4 and 3.11)</u>

The DWPF must demonstrate that controlling the as-purchased canister dimensions will ensure that the canistered waste forms comply with the WAPS. This will be accomplished with the following objectives:

- Verify that canister processing does not cause damage to the canister which could affect its ability to comply with the WAPS.

- Confirm that canister glass filling has no significant effect on canister dimensions and that the final canister dimensions (including weight) comply with the WAPS. This includes ensuring that the canister stands upright without support on a flat horizontal surface.

The acceptance requirement for this testing is that the canister dimensions must meet the WAPS after filling as stated below:

canister length - 3.000 m (+0.005 m, -0.20 m)
canister diameter - 61 cm (+1.5 cm, -1.0 cm)
canistered waste form weight - less than or equal to 2500 kg
overall dimensions - the canistered waste form must fit into a right circular cylinder, 64.0 cm in diameter and 3.01 m in length
The canister must also stand upright without support on a flat horizontal surface.

Reporting - Production Records

The WAPS require reporting of production data in the Production Records. During Qualification Runs, the DWPF will confirm that the DWPF is capable of collecting the necessary information to produce the Production Records as required by the WAPS. This includes using the operating procedures and administrative controls expected to be used during Radioactive Operations.

There is no specific acceptance requirement; however, the objective discussed above must be met.

Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

SEP 20 2018

Mr. Thomas Foster
President and Project Manager
Savannah River Remediation, LLC
Savannah River Site
Aiken, SC 29808

Dear Mr. Foster:

SUBJECT: Request for Concurrence of revisions to the Defense Waste Processing Facility (DWPF) Waste Form Compliance Plan (WCP) and Waste Form Qualification Report (WQR) volumes 2, 4, 5, 6 and 11 (Letter, Foster to Folk, SRR-2017-00017, dated 12/14/17)

The Department of Energy (DOE) has concluded the review of the subject changes to the WCP and WQR volumes 2, 4, 5, 6 and 11 as outlined in the enclosed memorandum and concurs with the changes. These revisions incorporated changes to the DWPF WCP and WQR documents, used to demonstrate compliance with the requirements in the DOE Waste Acceptance Product Specifications (WAPS) for Vitrified High-Level Waste Forms. Specifically, they incorporated the results from the updated durability, viscosity and liquidus models developed to address changes to the DWPF chemical flowsheet by startup of the Salt Waste Processing Facility including a higher titanium limit; as well as changes associated with transitioning to a glycolic acid flowsheet from a formic acid flowsheet. The other major change was the elimination of analyses performed on DWPF pour stream glass samples and the performance of the Product Consistency Test (PCT) on the sludge batch qualification sample.

The review concluded that proposed revisions to the WCP and WQR are appropriate. Changes were adequately documented in the WCP and WQR and supporting reports. Therefore, DOE believes that the revisions do not impact the ability of canistered DWPF waste glass to meet requirements of the Environmental Management WAPS nor the likelihood of acceptance in a future disposal facility, once available.

The action taken herein is considered to be within the scope of work of the existing Contract and does not authorize the Contractor to incur any additional costs or delay delivery to the Government. If the Contractor considers that carrying out this action will increase Contract costs, delay any delivery, or require the submission of a baseline change proposal, the Contractor shall not implement this technical direction and shall promptly notify the Contracting Officer's Representative orally, confirming and explaining the notification in writing to the Contracting Officer within five (5) working days. If the Contractor accepts the direction contained herein, then the Contractor waives any right to an equitable adjustment under the Contract arising from the technical direction. Following submission of the written notice of impacts, the Contractor shall await further direction from the Contracting Officer.

If you have any questions, please contact me, or have your staff contact Roberto Gonzalez at (803) 208-6168.

Sincerely,

James L. Folk, Jr.
Contracting Officer's Representative

WDPD-18-46

Enclosure:
Memo Senderling to Folk

cc w/enclosures:
M. A. Schmitz, SRR
J. Bair, SRR
J. Ray, SRR
P. Hill, SRR
S. P. Fairchild, SRR
L. Ling, SRR
D. Quinn, SRR
T. England, SRR
M. Mahoney, SRR
G. D. Barker, SRR
C. Hammond, SRR

Department of Energy
Washington, DC 20585

September 10, 2018

MEMORANDUM FOR JAMES FOLK
ASSISTANT MANAGER
WASTE DISPOSITION PROJECTS
SAVANNAH RIVER OPERATIONS OFFICE

FROM: MARK SENDERLING
DEPUTY ASSISTANT SECRETARY FOR
WASTE AND MATERIALS MANAGEMENT

SUBJECT: Concurrence on Revisions to the Defense Waste Processing Facility Waste Form Compliance Plan and Waste Form Qualification Report

This memorandum documents the Office of Environmental Management (EM) Headquarters' (HQ) review of revisions to the Defense Waste Processing Facility (DWPF) Waste Form Compliance Plan (WCP) and Waste Form Qualification Report (WQR) volumes 2, 4, 5, 6, and 11. The purpose of the revisions were to update results to the DWPF chemical flowsheet to incorporate changes due to the startup of salt waste processing and changes with transitioning to glycolic acid; eliminating analysis of pour stream glass samples and sludge batch qualification samples as part of the DWPF Glass Product Control Program; and changing the reporting requirement for radionuclides for canisters poured after 2015.

HQ's review is complete and concludes that proposed revisions to the WCP and WQR are appropriate. The site's bases for all changes was adequately documented in the WCP and WQR and supporting reports. Therefore, HQ believes that the revisions do not impact the ability of canistered DWPF waste glass to meet requirements of the EM Waste Acceptance Product Specifications (WAPS) nor the likelihood of acceptance in a future disposal facility, once available.

The review was conducted in accordance with applicable quality assurance procedures. The review team included members with expertise in appropriate technical and programmatic disciplines. A summary of the review, the process used, the review criteria, and results of the review is attached.

If you have any questions, please contact me at (202) 586-0785.

cc: S. Schneider, EM-4.23
S. Gomberg, EM-4.23
M. Zenkowich, EM-3 (SRS Liaison)
R. Murray, EM-3.113
R. Gonzalez, SRS