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DRAFT

WASTE FORM COMPLIANCE PLAN

for the

DEFENSE WASTE PROCESSING FACILITY

DWPF WASTE FORM COMPLIANCE PLAN

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ITEM TITLE: WASTE ACCEPTANCE PROCESS

The Department of Energy currently has approximately 100 million liters of high-level radioactive waste in storage at the Savannah River site. These wastes, which are generated during the production of nuclear materials for defense needs, have been stored as alkaline slurries in large carbon-steel tanks since the mid-1950's. This 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 construction and retirement 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 lead to a decision to build a Defense Waste Processing Facility to convert the easily dispersed liquid waste to 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, several independent review groups, and the Nuclear Regulatory Commission (NRC).

In their comments on the Environmental Assessment, the NRC also strongly urged the Department of Energy to continue the program of site-specific repository testing which had already been initiated. The need for such a program was made more pointed by the passage of the Nuclear Waste Policy Act of 1982 which mandated that all high-level waste would be sent to a federal repository for disposal. In 1985, the President ratified the decision to send this defense-related waste to a civilian repository. The Department of Energy, recognizing that start-up of the DWPF (currently scheduled for 1990) would considerably precede licensing of a repository, instituted a Waste Acceptance Process (WAP) to ensure that canistered waste forms would be acceptable 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 (RW) created

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the Waste Acceptance Committee (WAC) which was responsible for defining the minimum requirements which canistered waste forms must meet to be compatible with any of the media that were being considered for the first repository. The WAC, with representatives from the repository projects and the waste form producers, developed the Waste Acceptance Preliminary Specifications (WAPS) which identified these minimum requirements. A copy of the WAPS is included as Appendix 1.100.1, for reference. The WAPS have been revised to reflect the selection of the Nevada Nuclear Waste Storage Investigations Project (NNWSI) as the sole repository project. The specifications will not become final until NNWSI receives a license from the NRC.

The Waste Acceptance Preliminary Specifications (WAPS) are divided into four sections dealing with the waste form (borosilicate glass), the canister, the canistered waste form, and quality assurance of Waste Acceptance Process activities. The DWPF will document its compliance with the WAPS in the Waste Form Compliance Plan (WCP), the Waste Form Qualification Report (WQR), and in the Production Records, as required in the 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. It has been prepared for the DWPF by the Savannah River Laboratory (SRL). The WCP is being maintained by the Savannah River Laboratory, and updated as necessary.

The Waste Form Qualification Report (WQR) will be a compilation of of the results of those testing and analysis programs identified in the WCP which are common to all DWPF canistered waste forms. It will also contain the results of site-specific testing (as requested by the NRC) which support the acceptability of the DWPF product. The WQR will provide detailed evidence that the DWPF product will be in compliance with each specification, and will be compatible with the tuff repository environment. Parts, or all, of the WQR may also be used in gaining approval for startup of the DWPF, and in licensing of a repository in tuff.

The WQR will be prepared in a phased manner. Initial draft sections, primarily those summarizing work performed for the DWPF by

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SRL, will be issued for review and comment as soon as they are prepared. A first draft addressing all of the WAPS is currently scheduled for completion in September, 1989, prior to the initiation of non-radioactive testing in the DWPF. At the completion of non-radioactive testing, and before the initiation of radioactive operations, the DWPF will issue a draft WQR summarizing all of the information available. However, it is anticipated that some parts of the WQR (for example, a report on level detection by gamma emission from the canister) will not be completed until after the start of radioactive operations. Thus, work on the WQR is likely to continue even after facility startup. SRL will prepare an initial draft summarizing the results of their work performed for the DWPF. SRP-DWPF will then be responsible for maintenance and preparation of subsequent drafts.

The Production Records (PR) are documents that describe the contents of specific individual canistered waste forms. Prepared and maintained by the Savannah River Plant, the Production Records will summarize the detailed records of production of each canistered waste form, and will provide the means to retrieve those records, if necessary. Thus, the Production Records will be the primary documentary evidence of the acceptability of individual canistered waste forms.

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According to the Waste Acceptance Preliminary Specifications (see Appendix 1.100.1), this document, the DWPF Waste Form Compliance Plan (WCP), is to perform two functions. First, it is to provide general information about the DWPF process and product to facilitate planning by the repository project, Nevada Nuclear Waste Storage Investigations Project (NNWSI). This information is either provided as required, or a program and schedule for obtaining the required information is provided.

Second, the WCP is to provide a detailed description of the methods by which the DWPF will demonstrate compliance with each specification in the WAPS. The initial drafts of the WCP have concentrated on outlining DWPF's strategy for satisfying the requirements of the Waste Acceptance Preliminary Specifications (WAPS), based on the assumption that decisions on methods are best made as part of an integrated management plan. Initial review of the WCP by the Waste Acceptance Committee, in September, 1987, indicated general approval of the strategy proposed by the DWPF, but pointed out that the version of the WCP reviewed (Revision 5) did not contain the level of detail required by the WAPS. Revision 6, retained the management planning aspects of the initial drafts, but included detailed discussions of the methods to be used to demonstrate compliance. This version, Revision 7, addresses the WAPS as revised to reflect the amendments to the Nuclear Waste Policy Act of 1982, and comments by NNWSI on the Draft WCP. It also contains updated information about the DWPF product.

The overall strategy for complying with the WAPS is to assure the quality of the product by a combination of component specifications and process controls. Many of the specifications in the WAPS require that the canister and waste form are 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 operation. 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 is organized in a Part and Item format to enable easy concurrence with individual specifications. The revision number

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found in the heading of each page indicates the number of revisions that particular item has been through. This phased acceptance is intended to expedite the approval process while assuring thorough review. Following this Introduction, Part 2 briefly describes the DWPF process. The remaining parts are organized around the four sections of the Waste Acceptance Preliminary Specifications: waste form, canister, canistered waste form, and quality assurance. Within each part, each WAPS specification is addressed as a separate item. For each specification, the statement of requirements from the WAPS and the corresponding rationale is first presented in bold-face type. 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, or which is likely to be assigned, responsibility for completing each task is also indicated on the diagram. The Savannah River Plant is responsible 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 constitute a definition of the content of the WQR and the Production Records. Appendix 1.200.1 contains a description of the content of the Production Records, as required by the WAPS.

The DWPF Integrated Cold Runs will be of great importance for demonstrating compliance. Planned to begin in late 1989, the methods and control strategies for DWPF operation will be implemented, tested, and demonstrated. A summary of DWPF Integrated Cold Run activities relevant to the Waste Acceptance Process is included as Appendix 1.200.2.

In general, precise identification of some of the activities ne-

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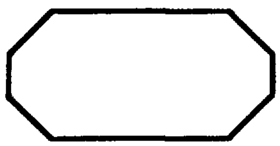
cessary to demonstrate compliance with a given specification will depend on the results of previous actions. It will be the responsibility of the organization assigned to carry out any task in the WCP to identify further actions for each specification, and to determine whether the results of the task necessitate changes in the compliance strategy (see Part 6, Item 700). SRP-DWPF (with SRL's assistance) will assign responsibilities for these new tasks as they are identified.

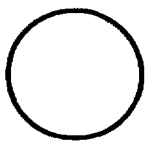
As recognized in the Introduction of the Waste Acceptance Preliminary Specifications, some individual canistered waste forms may not comply with the specifications in every respect. For these cases, DWPF will identify nonconformances and propose a course of action to allow final disposal. This will be submitted to DOE-Savannah River Operations Office for review, as outlined in Part 6, Item 800. DOE-SROO is responsible for development of procedures governing communications with, and review by, other organizations in DOE and/or other government organizations. It is anticipated that they will gain the consent of other affected organizations before approving proposed dispositions of nonconforming canistered waste forms.

It is also anticipated that the WCP may require revision after approval by SROO, for example when the preliminary specifications become more 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-Savannah River Operations Office for review, as outlined in Part 6, Item 700. DOE-SROO is responsible for development of procedures governing communications with, and review by, DOE and/or other organizations.

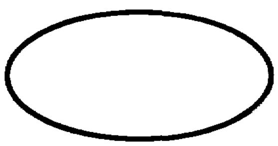
FIGURE 1.200.1 Symbol key for logic diagrams



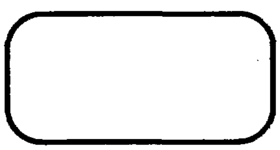
Tasks to be documented in the Waste Form Qualification Report.



DWPF Hot Startup.



Tasks following DWPF Hot Startup to be documented in the Production Records.



All other tasks.

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<u>End of canister cooling after filling</u>

Transfer of the canistered waste form from the Melt Cell to the Canister Decontamination Chamber is not allowed until the canister temperature is below 100°C. This limit is to prevent generation of steam during decontamination of the canister. Thus, this transfer to the Canister Decontamination Cell provides a convenient definition of the end of cooling after filling.

<u>Design-basis glass</u>

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. It is based on an early (ca. 1980) set of assumptions about nuclear fuels production and waste generation at the Savannah River Plant. While it is no longer an accurate projection of the glasses to be produced in 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.

<u>Frit</u>

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

<u>Integrated Cold Run</u>

Before the DWPF begins radioactive operations, the integrated operation of the equipment and process will be extensively tested. An important part of this Integrated Cold Run will be directed to demonstrating the ability of the DWPF process and facility to comply with the Waste Acceptance Preliminary Specifications. A summary of the Integrated Cold Run is included in Appendix 1.200.2.

<u>Macro-batch</u>

In the SRP Tank Farm, the feed to the DWPF will remain constant for extended periods of time. The sludge portion of the waste will change about every two to three years, while the precipitate

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portion of the waste will change every four months. Thus, the feed from the Tank Farm to the DWPF will be constant over a period of about four months at a time. This constant feed to the DWPF constitutes a macro-batch.

PHA

The soluble portion of SRP waste will be treated with sodium tetraphenylborate and sodium titanate to remove radioactive cesium and the traces of other radionuclides it contains. In the DWPF, most of the organic material will be removed from the precipitate by hydrolysis with formic acid. The aqueous fraction of the hydrolysis process, or PHA material, will be mixed with the sludge and frit to produce melter feed.

Production Records

The Production Records (PR) are documents that describe the 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.

Reference glasses

The Waste Acceptance Preliminary Specifications require the DWPF to project the range of glass compositions to be produced in the DWPF. The reference glasses represent extreme points in that range of compositions. The reference glasses will be used for qualification testing of the DWPF product.

Sludge

The insoluble portion of SRP 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.

Tank Farm

Currently, SRP high-level radioactive waste is stored in large (up to 5,000,000 L) carbon-steel tanks on site. The areas containing

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these tanks are known as the Tank Farms.

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 set of Waste Acceptance Process activities are identified and described in the Waste Form Compliance Plan.

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ITEM TITLE: OVERVIEW OF DWPF PROCESS

I. INTRODUCTION

At the Savannah River Plant (SRP) in Aiken, South Carolina, the residue of over thirty years of reprocessing of irradiated nuclear fuels for national defense purposes is currently stored as an alkaline slurry. In the Defense Waste Processing Facility (DWPF), the SRP 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 waste immobilization process is shown in Figure 2.100.1.

II. WASTE PROCESSING

Waste Pretreatment

The SRP waste is currently stored on site in carbon steel tanks and exists in three forms: sludge, saltcake, and salt solution. The sludge, comprising approximately 10 vol% of the stored waste, consists primarily of precipitates of the hydroxides of iron, aluminum, and manganese. The salt is largely sodium nitrate, sodium nitrite, sodium aluminate, and sodium hydroxide. The sludge contains most of the radioactivity and essentially all of the long lived radionuclides and actinides in the waste; the salt supernate fraction contains the remaining radioactivity, predominantly cesium-137.

The salt solution is decontaminated for disposal as low-level waste by precipitating the radionuclides. Dissolved salt solutions are pumped to an existing waste tank outside the vitrification building for pretreatment. Here a solution of sodium tetraphenylborate is added. Insoluble salts of K, Cs, and NH_4 (if present) form a precipitate. At the same time a small amount of sodium titanate slurry is added to adsorb remaining traces of soluble Sr and Pu in the salt solution. The precipitate slurry is concentrated by continuous filtration to 10 wt.% solids, washed to a low soluble salt level, and pumped to the DWPF where it is incorporated into the borosilicate glass. The decontaminated salt solution is blended with cementacious slag, flyash and cement in a

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separate facility for disposal as low-level waste.

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, transfer it to another waste storage tank where it will be agitated, and then to feed the DWPF from this homogenized tank for a period of 2 - 3 years.

Precipitate Processing

Within the vitrification building, tetraphenylborate salt is further processed to remove most of the organic carbon. About 90 % of the phenyl groups on the organic salt are converted to an immiscible benzene phase by a formic acid hydrolysis process. The aqueous product phase contains the cesium and other metals as soluble formate salts, boric acid, excess formic acid, and about 10% of the original phenyl groups in water-soluble forms such as phenol and phenylboric acid. The benzene is steam distilled, further decontaminated if necessary, and incinerated as a low-level waste. The aqueous product and the insoluble titanate containing the radioactivity are collected and fed to the Sludge Receipt and Adjustment Tank (SRAT) prior to vitrification.

Sludge Processing and Adjustment

The washed sludge slurry and the precipitate hydrolysis product are mixed together in the Sludge Receipt and Adjustment Tank (SRAT). Formic acid is also added to the SRAT which reduces the mercury to the elemental state. The formic acid also reduces the yield stress of the slurry, provides a reductant to the melt which minimizes foaming, and reduces ruthenium volatilization. The mercury is steam distilled from the slurry and eventually recovered in reusable, metallic form.

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III. 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 90% of the necessary frit is pumped directly to the SME. The remaining 10% of the frit is first used for canister decontamination (frit blasting), and then is added to the SME. The frit-waste-formate slurry is then thickened to about 50 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 SRP waste is accomplished in a slurry-fed, Joule-heated melter. The feed slurry is introduced from the top of the melter and forms a crust, or cold cap, on the surface of the melt pool as the water is evaporated and removed via the off-gas system. Two pairs of diametrically opposed electrodes supply about 150 kw of 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 waste-borosilicate glass matrix. For a nominal pour rate of 100 kg/hr, and a nominal glass melt weight of 6500 kg in the melter, the 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 the bottom of the DWPF melter through a riser which is slanted upward, and overflows into a pour spout connected to a stainless steel canister. A schematic diagram of the canister filling operation is shown in Figure 2.100.2. Pouring is accomplished by drawing a vacuum on the pour spout relative to the melter. During, and for ~ 30 minutes after completion of the fill, the canister is vented to the off-gas system to collect volatile radionuclides (such as Cs-137) which may be emitted from the surface of the glass. The canister is then rotated from beneath the pour spout on a turntable. When the canister is

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rotated from under the melter, the canister is temporarily sealed with a tapered plug that shrink-seals as cooling continues, creating a water tight seal (better than 10^{-4} atm-cc He/sec).

Glass filling is monitored by weight and glass level in the canister. The glass level is determined four ways: 1) by measuring intrinsic gamma radiation from the waste glass through a vertical series of collimators, 2) by measuring absorption of fast neutrons from a fixed Cf-252 source, 3) by visually observing the color change of the canister external surface, due to the heat from the molten glass, and 4) by calculating the level from glass density and weight measurements.

Canister Decontamination

Frit slurry blasting is used to remove contamination and metal oxides from the canister surface. Cleaning is performed by rotating the canister in an enclosed chamber and using air injected wet glass frit blasting on all exposed surfaces. The used frit slurry is then sent to the SME for melter feed preparation.

Final Canister Closure

The canister is sealed by welding a 12.9 cm diameter plug into the canister nozzle using an upset resistance weld. After 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 330,000 newtons is applied to the plug, a current of 240,000 amperes is passed through the plug and nozzle. The 40-cm long 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. Weld quality is ensured by recorded verification that the important parameters (force, current, time) were within predetermined acceptable ranges. The weld is then visually inspected to verify inset and symmetry. Techniques to seal canisters with out-of-specification welds have been developed and demonstrated.

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Interim Storage

The filled and decontaminated canisters are moved by a shielded transporter and stored in an air-cooled storage building. A ventilation system consisting of exhaust fans and HEPA filters is used to create a slight negative pressure in the canister storage area and to prevent spread of contamination, in case of an unexpected event.

IV. REFERENCES

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.**

FIGURE 2.100.1 IMMOBILIZATION OF SAVANNAH RIVER PLANT WASTE

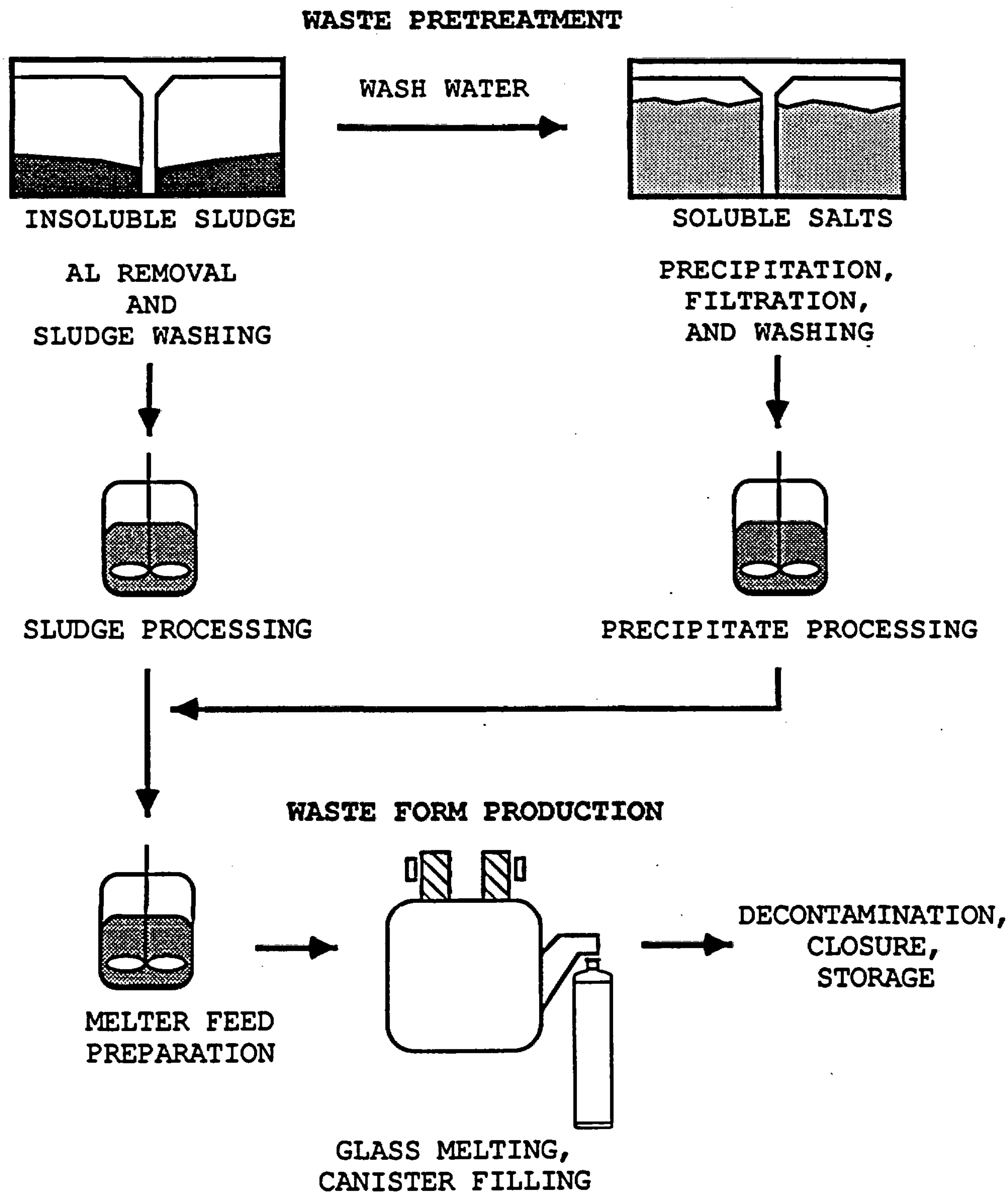
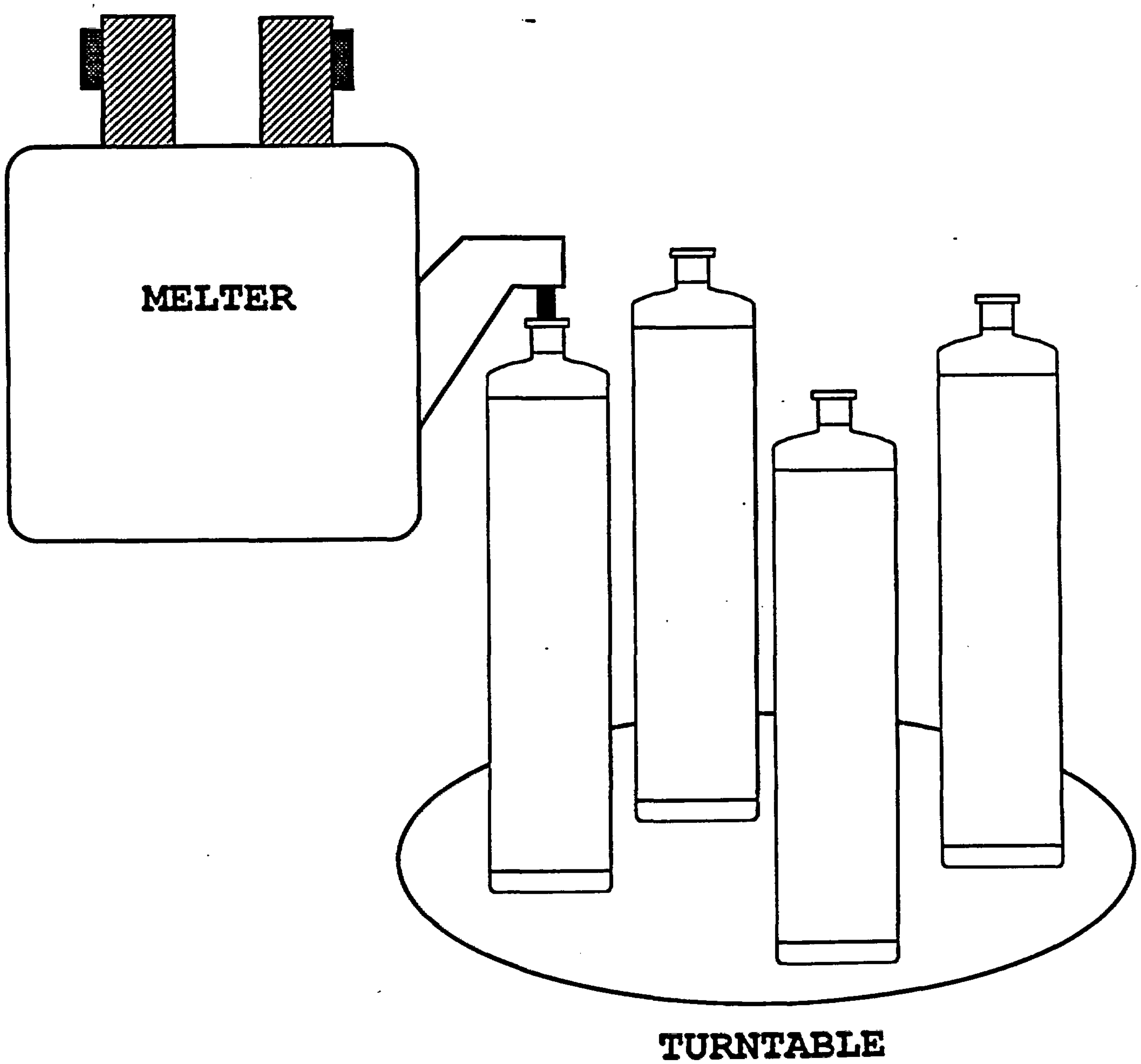


FIGURE 2.100.2 DWPF CANISTER FILLING OPERATION



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.1.1 CHEMICAL COMPOSITION PROJECTIONS

1.1 CHEMICAL SPECIFICATION

The waste form for DWPF is borosilicate waste glass.

1.1.1 Chemical Composition Projections

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

Rationale

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

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

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

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of interest.

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

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

Compliance Strategy

A report defining reference glass compositions will be prepared. The compositions thus defined will span the range of compositions of glass expected to be produced in the DWPF. The reference compositions will be defined based on the inventory of waste currently stored in the tanks at SRP, the composition of that waste, anticipated blending schemes for the waste streams, the expected composition of the glass frit to be used, and estimates of the amount and composition of waste to be generated at SRP in the future.

The range of glass compositions will be of a broad nature because of the uncertainties in the assumptions. In particular, the estimates of future waste generation and composition are dependent on future national defense needs which have not yet been defined. Similarly, unforeseen events may necessitate changes in blending schemes. Thus, 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

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of compositions defined as above will include all glasses produced in the DWPF. If future site processes significantly change so that the composition of the glass falls outside the range of reference compositions, then disposal of this glass will be accomplished according to the procedure in Part 6, Item 800.

Implementation

The plan being followed to satisfy this specification is outlined in Figure 3.100.1. The initial action was to identify the important factors affecting composition projections. These important factors are:

- The composition of the waste currently stored in the tanks, and identification of its sources.[1-5]
- The amount of waste currently stored in the waste tanks.
- The anticipated blending schemes for waste currently stored.
- The types of wastes expected to be generated in the future.
- The compositions of those waste types.
- The algorithm(s) to be used to generate a glass former composition from a given waste composition.

On a weight basis, DWPF glass will consist of approximately 64 wt% borosilicate glass frit, 8 % precipitate hydrolysis product, and 28 % sludge (see Part 2, Item 100). The glass frit and the precipitate hydrolysis product (PHA) together make up what is called the glass-former composition. The glass-former composition for the DWPF has been developed so that DWPF waste glass will have similar properties to simulated waste glasses previously developed for sludge-only processing.[6] This has been achieved by modifying the glass frit composition to take into account chahges in waste processing, such as the tetraphenylborate precipitation process. Properties which are controlled during modification of frit composition are chemical durability of the glass, viscosity of the glass, solubility of waste in the glass former, thermal stability of the glass, and reliability of processing behavior and product

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properties.[7,8]

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. As of October 31, 1987, it was estimated that the 46 high-level waste tanks contained 33,667,000 gallons of waste. Processes, histories and methods of waste handling at SRP indicate that several general types of wastes currently reside in the waste tanks:

- HM high heat waste (HM HAW)
- HM low heat waste (HM LAW)
- Purex high heat waste (Purex HAW)
- Purex low heat waste (Purex LAW)
- Zeolite resin
- Coal and sand
- Silver salts
- Supernatant salt solutions (primarily sodium salts). These solutions will be decontaminated with sodium tetraphenylborate and sodium titanate.

An Integrated Flowsheet computer model has been used to develop a material balance for the design of the DWPF at SRP. A modified version of this computer model, which incorporates recent modifications of both the DWPF and SRP processes which produce high-level waste, has been used to estimate the range of compositions of waste glass that will be produced in the DWPF. The model takes into account

- Sludge, slurry and salt precipitate compositions which are fed to the DWPF.
- Reactions in the DWPF which alter the chemistry of the feed streams.

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- 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-scale 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 eight 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:

- An overall blend of existing inventory.

- A blend of HM (high aluminum) waste that represents the upper design limit of glass viscosity that will be produced at DWPF.

- A blend of Purex (high iron) waste that represents the lower design limit of glass viscosity that will be processed at DWPF.

Accurate projection of the chemical composition of future waste is difficult because of possible SRP processing changes which would affect waste generation. The composition of wastes to be generated in the future has been estimated based on historical usage of process chemicals, modified by recent changes which have occurred in the waste generating processes. The four extremes of HM HAW and LAW, and Purex HAW and LAW have been used as bounds for future waste generation. As additional experience is gained with the DWPF process, additional compositions may be added to those reported here which would reflect, for example, process upset conditions.

Samples of simulated waste glass of each of these reference compo-

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sitions will be prepared. These samples will be subjected to the thermal conditions expected during filling and cooling of DWPF waste glass in a canister, both at the surface of the canister and along the centerline. The microstructure of these glass samples will then be characterized using the methods referred to in Part 3, Item 600.

Documentation

The Waste Form Qualification Report will include a report on the reference glass compositions. These will span the ranges of glass compositions expected to be produced in the DWPF. The identity and expected amount of crystalline phases will also be reported.

References

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9. **Basic Data Report for the Defense Waste Processing Facility, Revision 90/91,** USDOE Report DPSP 80-1033, April, 1985.

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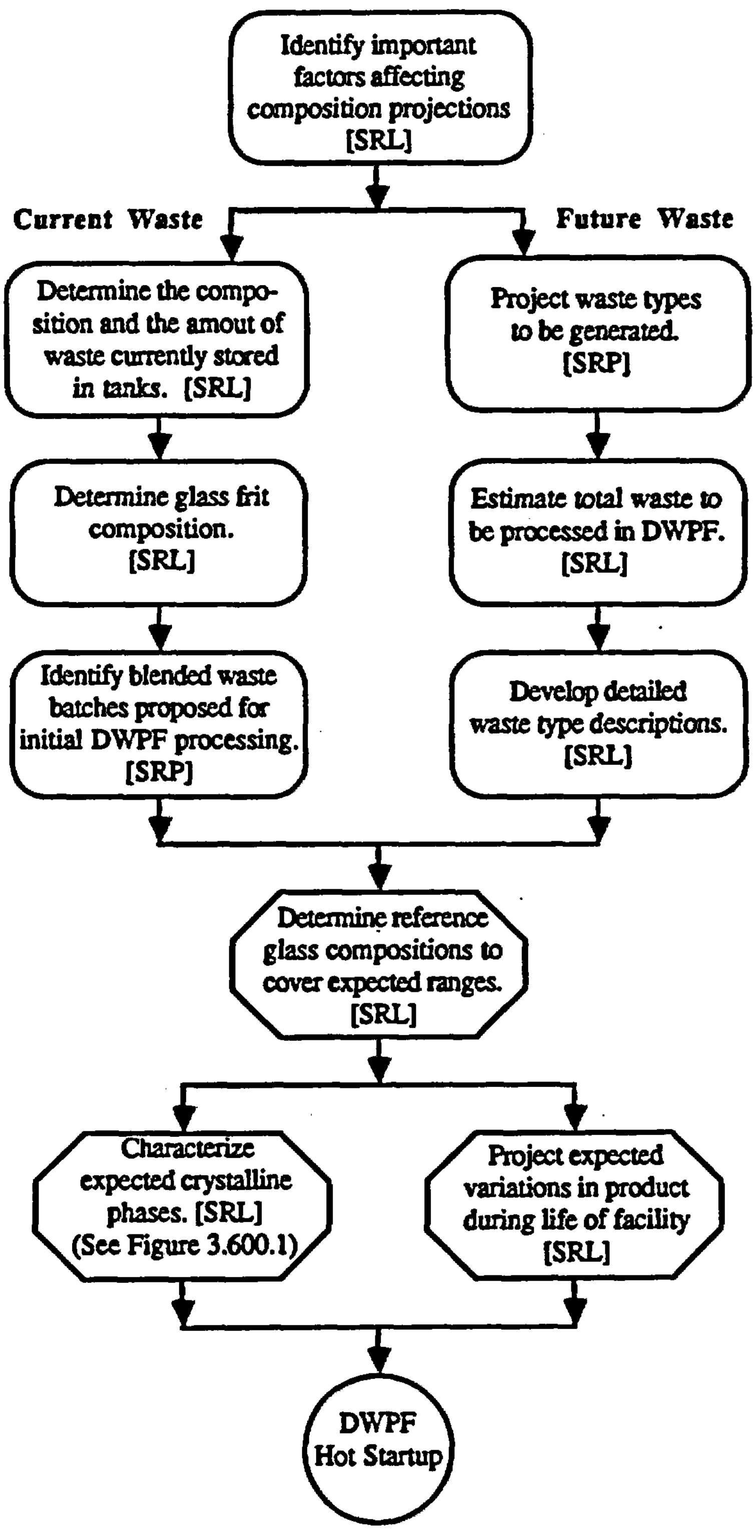
TABLE 3.100.1 Projected DWPF Waste Glass Compositions

MAJOR GLASS COMPONENTS weight %	CONSTITUENT SLUDGE TYPE						
	Blend	Batch 1	Batch 2	Batch 3	Batch 4	HM	Purex
Al_2O_3	3.98	4.87	4.46	3.25	3.32	7.08	2.89
B_2O_3	8.01	7.69	7.70	7.69	8.11	6.94	10.21
$BaSO_4$	0.27	0.22	0.24	0.26	0.38	0.18	0.29
CaO	0.97	1.17	1.00	0.93	0.83	1.00	1.02
$CaSO_4$	0.077	0.12	0.11	0.10	0.0034	trace	0.12
Cr_2O_3	0.12	0.10	0.12	0.13	0.14	0.086	0.14
CuO	0.44	0.40	0.41	0.40	0.46	0.25	0.42
Fe_2O_3	6.95	8.39	7.11	7.48	7.59	4.95	8.54
FeO	3.11	3.72	3.15	3.31	3.36	2.19	3.78
Group A*	0.14	0.099	0.14	0.10	0.20	0.20	0.078
Group B$	0.36	0.22	0.44	0.25	0.60	0.89	0.084
K_2O	3.86	3.49	3.50	3.47	3.99	2.14	3.58
Li_2O	4.40	4.42	4.42	4.42	4.32	4.62	3.12
MgO	1.35	1.36	1.35	1.35	1.38	1.45	1.33
MnO	2.03	2.06	1.62	1.81	3.08	2.07	1.99
Na_2O	8.73	8.62	8.61	8.51	8.88	8.17	12.14
Na_2SO_4	0.10	0.10	0.12	0.096	0.13	0.14	0.12
NaCl	0.19	0.31	0.23	0.22	0.090	0.093	0.26
NiO	0.89	0.75	0.90	1.07	1.09	0.40	1.21
SiO_2	50.20	49.81	50.17	49.98	49.29	54.39	44.56
ThO_2	0.19	0.36	0.63	0.77	0.24	0.55	0.011
TiO_2	0.90	0.66	0.67	0.66	1.02	0.55	0.65
U_3O_8	2.14	0.53	2.30	3.16	0.79	1.01	2.89

* Group A: radionuclides of Tc, Se, Te, Rb, Mo.

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

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

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

Compliance Strategy

During production, the composition of the glass will be determined as follows:

- Samples of the melter feed will be taken, and analyzed, throughout processing of each macro-batch.

- The composition of the glass produced will be calculated, based on a correlation between feed and glass composition.

- The composition of the entire group of canistered waste forms produced by a macro-batch will be reported as an average value for the entire macro-batch, with a standard deviation based on the range of values in the feed composition.

The correlation will be developed by SRL during pilot plant operations. The correlation will be verified during the DWPF Integrated Cold Run, when feed and glass samples can be routinely taken and analyzed. The precision and accuracy of the determination of the glass composition will be calculated based on the results of the DWPF Integrated Cold Run, and will be reported in the Waste Form Qualification Report.

The correlation between feed and glass composition, and therefore the accuracy of the reported composition will be continually upgraded by analyses of glass samples taken from the pouring glass stream. This is described in more detail in Part 3, Item 550.

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ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.200.1. The initial action taken was development of a strategy for determining glass composition during production, discussed below. The next tier of tasks involve development of analytical and calculational techniques to determine glass composition.[1] The final tasks before the initiation of radioactive operations in the DWPF are demonstrations of the strategy and methods developed, and determination of the precision and accuracy which will actually be realized during DWPF operations.

The DWPF has completed development of a strategy for determining the chemical composition of DWPF glass during production. The strategy (shown in Figure 3.200.2) is predicated on the facts that the sludge feed to the DWPF will be relatively constant over the life of each major sludge batch (2 - 3 years), and that the precipitate feed to the DWPF will be relatively constant over the life of each major precipitate batch (3 - 4 months). Samples from each major sludge and precipitate batch (macro-batch) will be taken from the tanks and analyzed to determine the major (those present in the glass at ≥ 0.5 wt %) nonradioactive elements. This information will also be used to develop frit composition specifications for the DWPF, and to procure analytical standards for DWPF use.

When processing of each macro-batch begins in the DWPF, the DWPF laboratory will analyze Melter Feed Tank samples to determine the actual content of the major nonradioactive 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 relative standard deviations of these measurements are expected to be less than 10%, for most of the elements, although elements near the 0.5 % threshold may be known less precisely.

During the Integrated Cold Runs, samples of feed and glass will be taken to verify the correlation developed in the laboratory. If deviations in this model are detected, the model will be modified to be consistent with the results. This should minimize the number of samples required during radioactive operation.

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When glass samples are taken in the DWPF, they will be sent to SRL for chemical and radiochemical analyses, and other testing (See Part 3, Item 550). A portion of each of the glass samples will be returned to the DWPF, and analyzed in the same manner as at SRL. These results will be used to verify and fine-tune the correlation between feed and glass composition. If major discrepancies between glass sample analyses and the calculated chemical composition are found, the glass will be sampled more frequently to improve the correlation between melter feed and glass to acceptable levels (See Part 3, Item 500).

As an example of the implementation of the DWPF strategy, each of the major elements in the design-basis feed (see Part 3, Item 100, Table 3.100.1) to the DWPF is identified, by source, in Table 3.200.1, along with the analytical technique which will be used to determine its concentration.[1-3]

Estimates of the precision and accuracy of the analytical methods themselves are shown in Table 3.200.2. These are based on experimental investigations of the ability of the methods developed for the DWPF to analyze glasses similar in composition to DWPF glass. The experiments were performed remotely in SRL's Shielded Cells Facility, and used the methods developed for the DWPF.

The values reported will also contain errors due to sampling. A remote sampling system for the DWPF has been developed and tested[4] (see Figure 3.200.3). The sample vial and valve arrangement are shown in Figure 3.200.4. Current estimates are that sampling contributes less than 5 relative % error to the reported values. These estimates are based on experimental data using the prototypical DWPF sampler, in a full-scale vessel similar to the Melter Feed Tank. More definitive estimates of the precision and accuracy of the reported glass compositions will be made during the Integrated Cold Run in the DWPF. These results will be reported in the Waste Form Qualification Report.

Documentation

The Waste Form Qualification Report will include a report on the methods to be used to determine the glass composition during production, as well as verification and validation of the methods.

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This will include determinations of the precision and accuracy of the selected methods from the DWPF Integrated Cold Run, as well as estimates of the errors due to sampling and analyses.

The Production Record for each canistered waste form will include the elemental composition of the glass. The values will be reported as the numerical average and standard deviation calculated from the individual elemental analyses for an entire macro-batch, expressed as oxides in the glass. This information will be calculated from analyses of samples from the Melter Feed Tank. The reported chemical composition will be the same for all canisters produced from a given macro-batch of feed.

This composition will have to be within the range of compositions projected for the DWPF, required to satisfy Specification 1.1.1. Development of this range is scheduled to be completed in January, 1988. If the composition is outside the projected range, then the batch of glass-filled canisters will be identified as nonconforming items, and then dispositioned according to the procedures outlined in Part 6, Item 800.

References

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2. 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).

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ITEM TITLE: 1.1.2 CHEMICAL COMPOSITION DURING PRODUCTION

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TABLE 3.200.1 Major Elements and Analytical Techniques for Design-Basis DWPF Feed

Component	Source	Technique*
Al	Sludge	ICP
B	Frit, salt	ICP
Ca	Sludge	ICP
Fe	Sludge	ICP
K	Salt	AA
Li	Frit	ICP
Mg	Frit, sludge	ICP
Mn	Sludge	ICP
Na	Frit, salt, sludge	ICP
Ni	Sludge	ICP
Si	Frit, sludge	ICP
Ti	Salt	ICP
U	Sludge	ICP

* ICP = inductively coupled plasma spectroscopy
AA = atomic absorption spectroscopy

TABLE 3.200.2 Representative Values for Precision and Accuracy of DWPF Analytical Techniques, Based on Analyses of Glass Standards*

Component	No. of Measurements	Standard† Wt%	Average Wt%	%RSD$
SiO_2	9	53.8	54.0	4.3
Fe_2O_3	9	12.9	13.0	3.7
Na_2O	9	10.4	10.32	6.4
B_2O_3	9	6.71	6.74	4.1
Li_2O	9	5.0	5.07	4.7
Al_2O_3	9	4.19	4.12	5.2
K_2O	19	3.18	3.30	9.5
MnO_2	12	3.14	3.03	1.4
CaO	9	1.54	1.60	5.8
MgO	9	1.02	1.02	4.1
TiO_2	14	0.88	0.95	7.0
ZrO_2	9	0.50	0.47	5.1

* Results from Reference 1.

† Different standards were used for these tests so that the tota- does not equal 100%.

$ Percent Relative Standard Deviation.

FIGURE 3.200.1 Tasks planned to satisfy Specification 1.1.2, Chemical Composition during Production

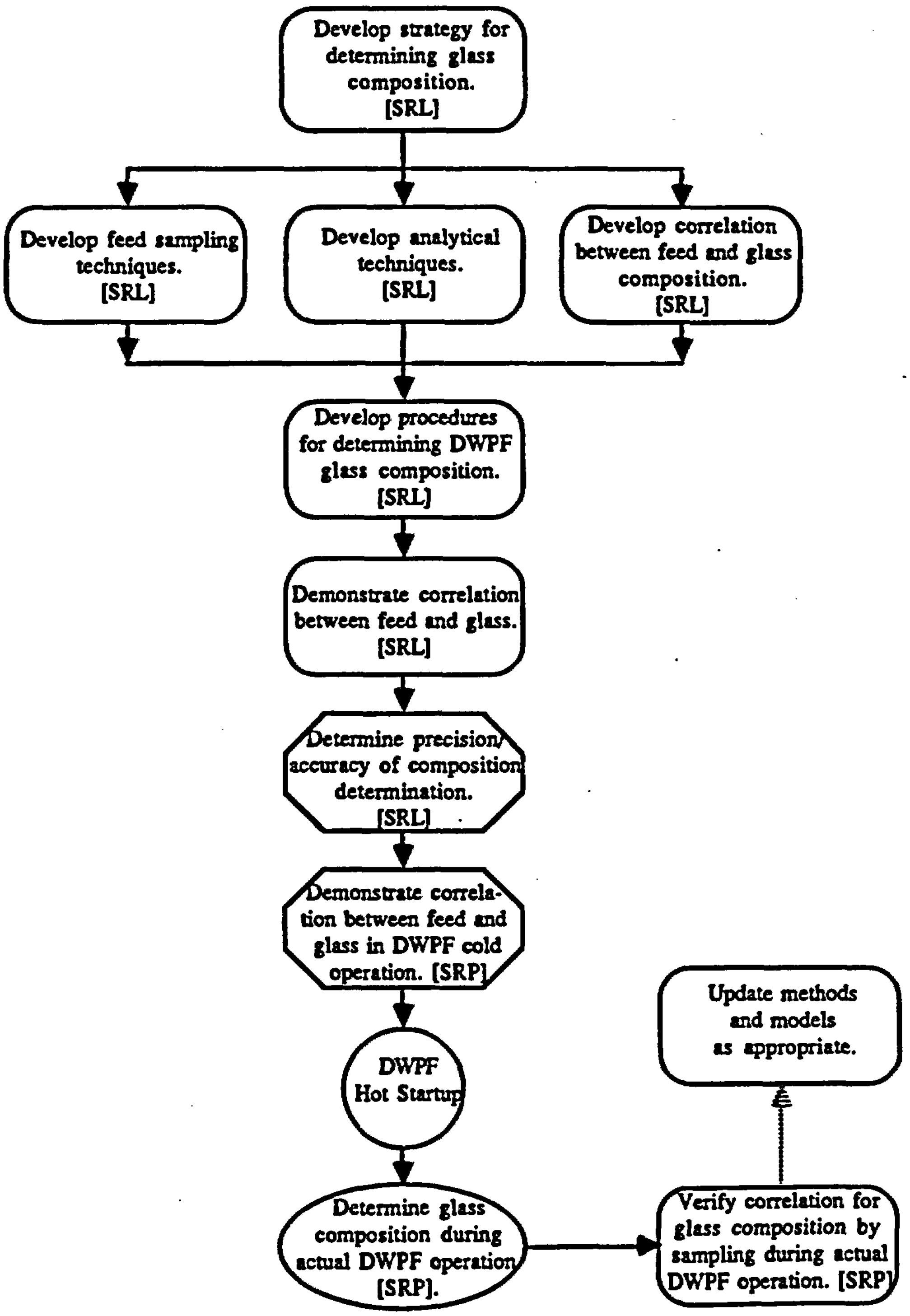
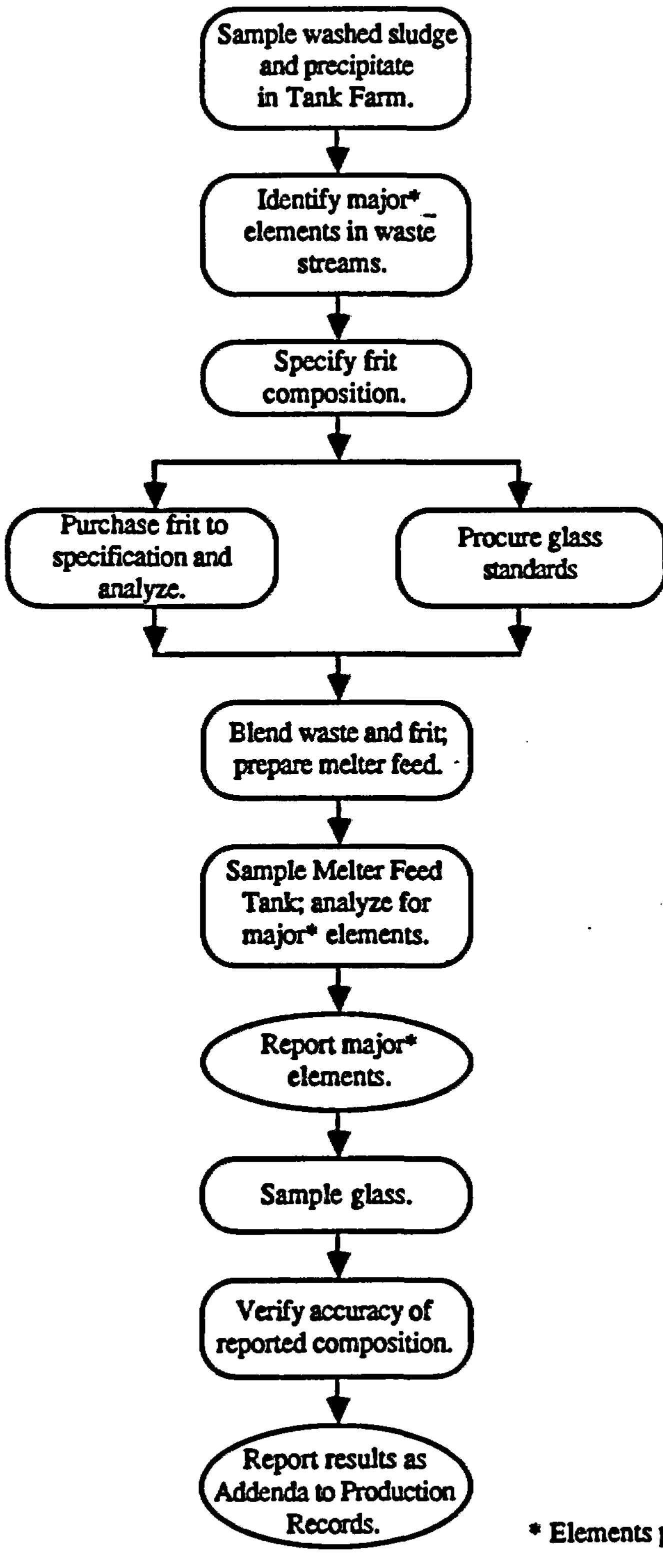


FIGURE 3.200.2 Strategy to Determine Chemical Composition of DWPF Glass during Production



* Elements present in concentrations ≥0.5 weight %

FIGURE 3.200.3 DWPF recirculating sample loop

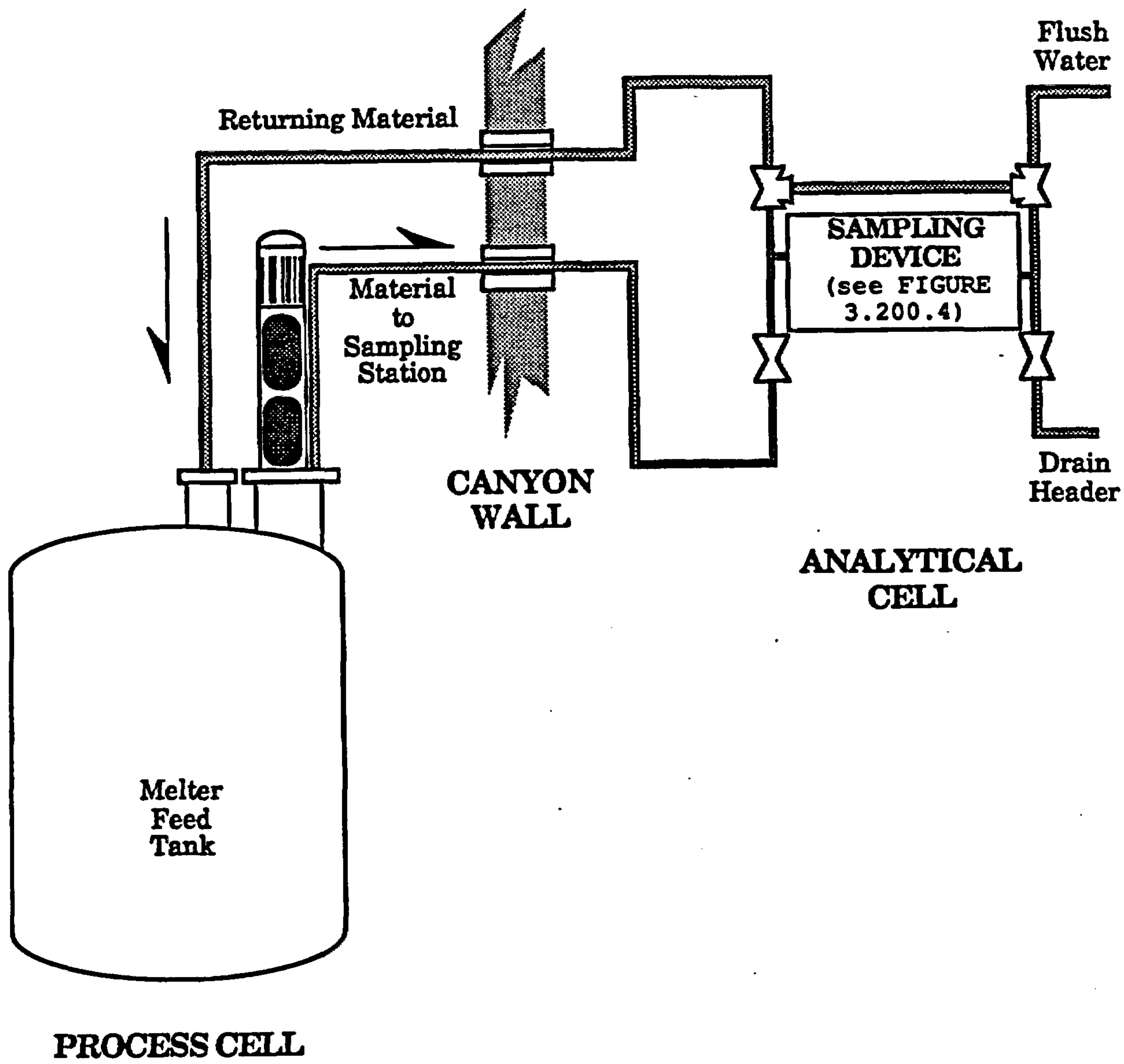
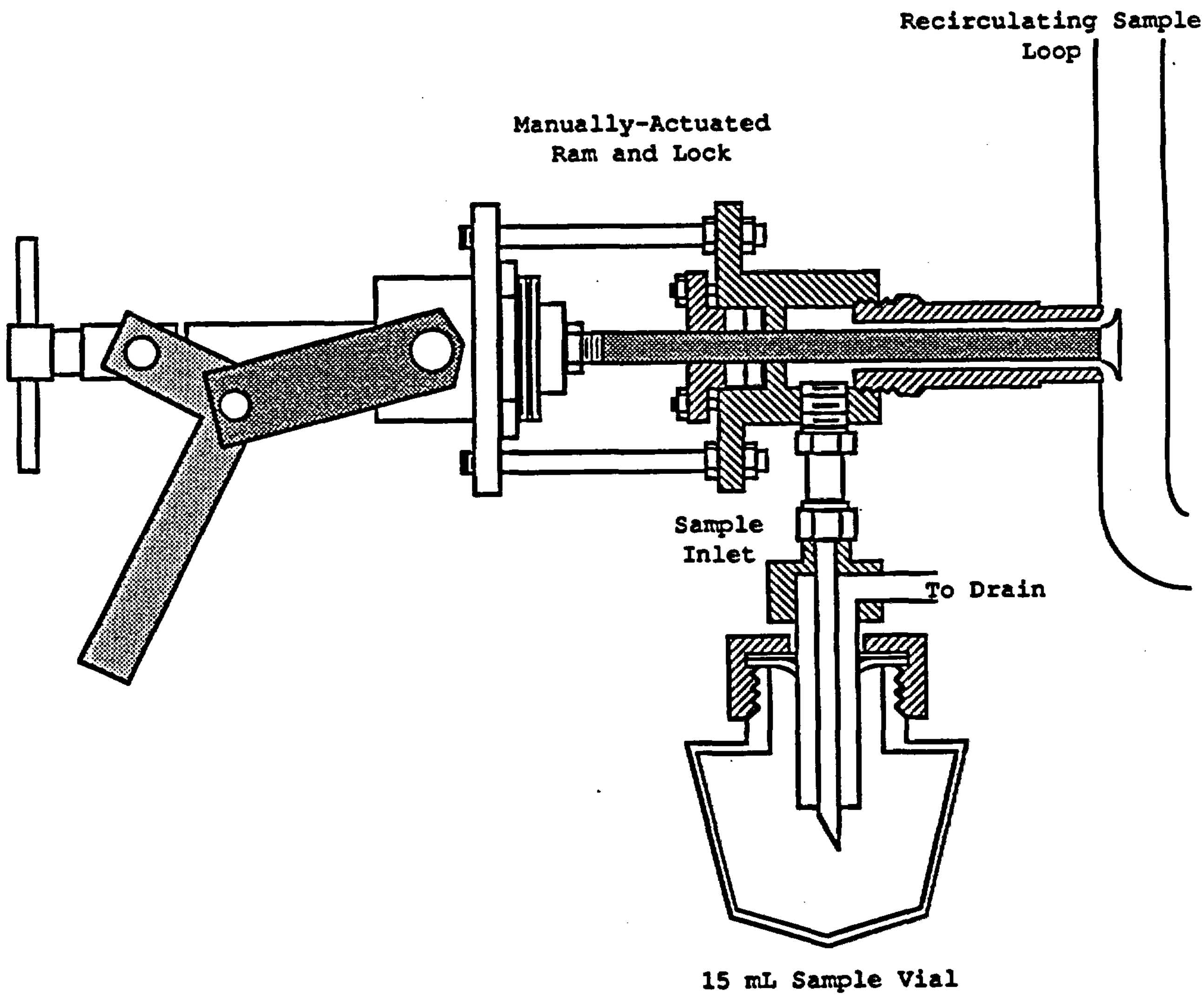


FIGURE 3.200.4 DWPF Remote Sample Valve



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.2.1 RADIONUCLIDE INVENTORY PROJECTIONS

1.2 RADIONUCLIDE INVENTORY SPECIFICATION

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

1.2.1 Radionuclide Inventory Projections

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

Rationale

The total radionuclide inventory is required for a determination of the producer's contribution to the repository source term for calculations to show compliance with 40 CFR 191 total release standards. A year was needed for indexing radionuclide inventory values. The year 2025 was chosen to serve this purpose. Inventory estimates for each canistered waste form are required to confirm that each canistered waste form falls within ranges considered in licensing, safety, and isolation assessments, and for estimates of releases under unanticipated processes and events, and accident scenario conditions. Expected variations in radionuclide inventories are necessary to adequately quantify uncertainties in radionuclide release estimates for repository performance assessments. The minimum concentration of 0.05 percent is needed to ensure that all isotopes of possible consequence to safety and

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

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

Compliance Strategy

Estimates of the total quantities of radionuclides to be processed into borosilicate waste glass will be based on the inventories of radionuclides currently stored in the waste tanks and on the anticipated waste generation at SRP in the future. Estimates of inventories of individual radionuclides expected to be present in each canistered waste form will depend not only on those two factors, but also on blending schemes for the waste streams.

Implementation and Status

The tasks planned to satisfy this specification are outlined in Figure 3.300.1. The initial action was to identify the important factors affecting radionuclide inventory projections. These important factors are:

- The radionuclide inventories of waste currently stored in the waste tanks. As of October 31, 1987, it was estimated that the 46 high-level waste tanks contained 33,667,000 gallons of waste. The curie content of the current waste inventory, estimated from analyses, is listed in Table 3.300.1.

- The projected future waste generation at SRP.

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- The anticipated blending scheme of waste currently stored.

- The curie balance projections used in forecasting radionuclide inventory.

There are several sources of information to be considered in making radionuclide inventory projections. These include the results generated by computer codes based on production, analytical data from waste samples, and the results from the DWPF curie balance and material balance calculations. Available data from all of the radionuclide projection sources will be compared to assure that the most reasonable value is used. If a good technical basis for choosing one value over another cannot be justified, the most conservative value will be chosen.

The DWPF design basis curie balance was developed to provide a basis for biological shielding, process cooling and environmental release requirements. This curie balance will also be used to project radionuclide content of future waste. SRP production forecasts are used to project the number of canisters that will be produced, using the same assumed product mix as in the design basis curie balance. Several assumptions were made in developing the design basis curie balance.

- A standard blend of waste streams containing various radionuclides.

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

- Soluble waste is aged 15 years to assure low concentrations of Ru-106.

Table 3.300.2 lists all the radionuclides, with a half life greater than ten years, which comprise at least 0.01% of the radionuclide inventory 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.

Predicting isotopic content of waste that has not yet been generated, with any degree of certainty, is not possible. However, if the assumptions made about future waste generation are correct,

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current experience indicates that actual radionuclide inventories will be within 25% of those predicted. When waste processing begins in the SRP Tank Farm in 1988, more complete and accurate information will become available.

Documentation

The Waste Form Qualification Report will include a report on the estimates of total quantities of radionuclides to be processed into borosilicate waste glass at DWPF, and on the estimates of inventories of individual radionuclides expected to be present in each canistered waste form. This report will include a description of the methodology used to develop the estimates. Relevant information from waste processing in the Tank Farm will be provided to the repository projects on an on-going basis by means of the Waste Form Compliance Plan and the Waste Form Qualification Report.

TABLE 3.300.1 SRP High-Level Waste Inventory as of October 31, 1987.

Number of tanks in service:	46
Total Volume of waste, gals:	33,667,000
Sludge heat output, Btu/hr:	6,307,500
Supernate heat output, Btu/hr:	963,500
Total heat output, Btu/hr:	7,271,000
Sr-89	171,900
Sr-90	136,500,000
Y-90	136,500,000
Y-91	453,100
Zr-95	971,000
Nb-95	2,104,000
Ru-106	5,227,000
Rh-106	5,227,000
Cs-137	140,600,000
Ba-137	129,400,000
Ce-144	60,010,000
Pr-144	60,010,000
Pm-147	62,450,000
Total curies, sludge plus supernate	739,624,000

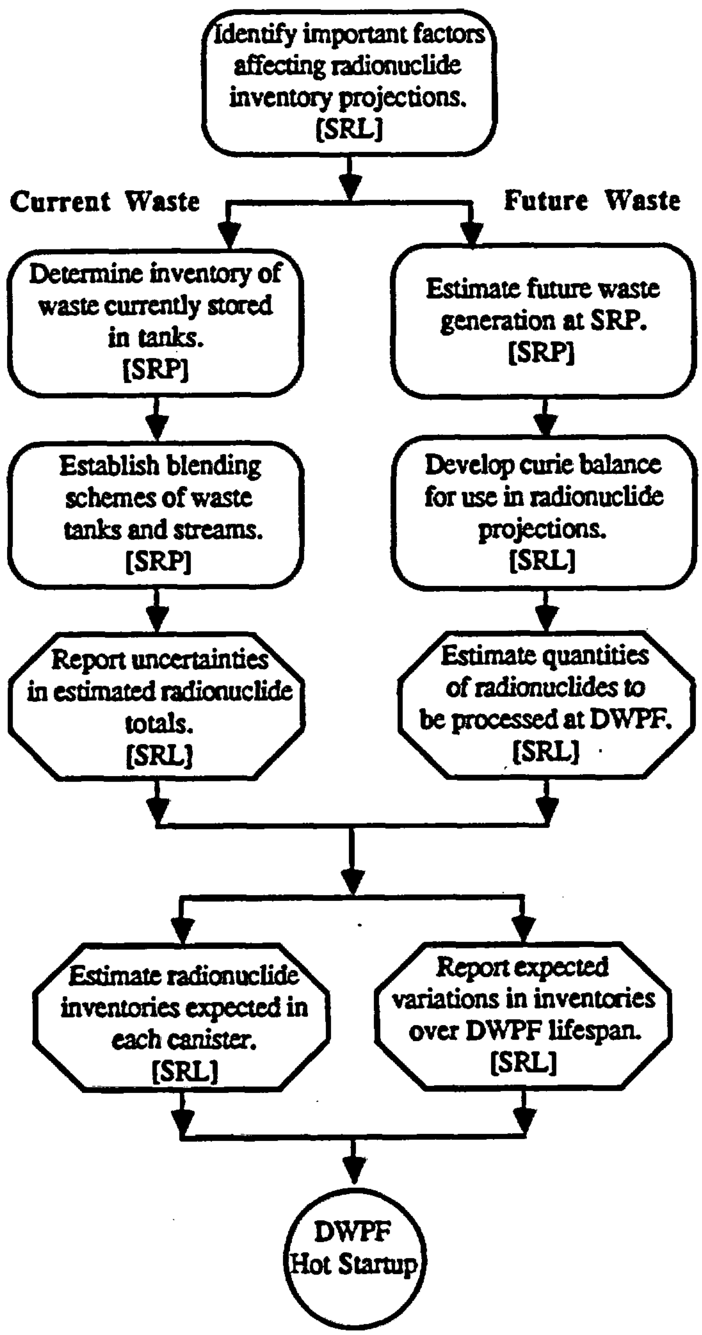
Note: 1 btu/hr = 0.2928 watts

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

Ni-59	Th-230
Ni-63	U-234
Se-79	U-238
Sr-90	Np-237
Zr-93	Pu-238
Nb-93m	Pu-239
Tc-99	Pu-240
Pd-107	Pu-241
Sn-126	Pu-242
Cs-135	Am-241
Cs-137	Am-243
Sm-151	Cm-244

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

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

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

Compliance Strategy

During production, estimates of the inventories of individual radionuclides in each canistered waste form will be determined from the radionuclide inventory in the feed, and a correlation will be established between feed and glass composition, as referred to in Part 3, Item 200. Determination of the radionuclide inventories in the feed will be done by a combination of analytical measurement and calculation. The techniques will be demonstrated in SRL's Shielded Cells Facility before radioactive operations begin in the DWPF. Initial estimates of the precision and accuracy of the techniques will be determined based on these demonstrations, and reported in the Waste Form Qualification Report.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.400.1. The initial action taken was development of a strategy for determining radionuclide inventories during production. This is shown in Figure 3.400.2. The next tier of tasks in Figure 3.400.1 require development of analytical techniques and methods of calculation to determine the radioactive content of the glass. The final tasks before the initiation of radioactive operations in the DWPF are demonstrations of the strategy and of the methods developed. The precision and accuracy which will actually be realized during DWPF operations will not be determined until after radioactive operations begin.

The DWPF has completed development of a strategy for determining the radionuclide inventory of DWPF glass during production. The strategy (shown in Figure 3.400.2) is similar to that for the chemical composition during production, in that it is based on the concept that the sludge feed to the DWPF will be relatively constant over the life of each major sludge batch (~2 years), and

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ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

that the precipitate feed to the DWPF will be relatively constant over the life of each major precipitate batch (~4 months). Samples from each major sludge and precipitate batch (macro-batch) will be taken from the tanks, and radiochemical analyses will be performed for those radionuclides which can be analytically determined in the individual waste streams. These radiochemical analyses will be used to develop correlation functions between radionuclides which can be analytically determined and those which are chemically similar, but cannot be measured directly. They will also be used to establish estimates of the precision and accuracy of the DWPF methods, many of which are still under development.

The DWPF will report, as the radionuclide inventory of the glass, the contents of all radionuclides listed in Table 3.400.1. Based on reactor codes used at Savannah River, each of these radionuclides has a half-life > 10 years and makes up at least 0.01 % (on a curie basis) of the radionuclide inventory of the reference glass, at some time between the time of production of the glass and 1100 years after production. The method by which the content of each of these radionuclides in the glass will be determined is listed in Table 3.400.2. The latter are subject to change because the reliability of the methods for many of the long-lived and very dilute radionuclides has not yet been established.

When processing of the macro-batch begins in the DWPF, the DWPF laboratory will analyze Melter Feed Tank samples for Cs-137, Sr-90, and gross α, and other specific radionuclides which can be detected by α- and γ-PHA. These will be used as direct input to the Production Records. The contents of other radionuclides in the glass will be based on the average of the results of the Tank Farm samples (converted to a glass basis) with a standard deviation based on, at a minimum, DWPF laboratory's Cs-137, Sr-90, and gross α analyses for the entire macro-batch. All of these values will be converted to a glass basis.

The data in Table 3.400.3 is an example of the application of the DWPF methods to samples of actual SRP waste glass, and can be used to estimate the precision of the methods which will be used.[2] The experiments were performed remotely in SRL's Shielded Cells Facility, and used the methods similar to those developed for the DWPF. As noted in Part 3, Item 200, sampling errors will also contribute to the uncertainty in the reported result.

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ITEM TITLE: 1.2.2 RADIONUCLIDE INVENTORY DURING PRODUCTION

When glass samples are taken in the DWPF, they will be sent to SRL for chemical and radiochemical analyses, and other testing (See Part 3, Item 550). A portion of each of the glass samples will be returned to the DWPF, and analyzed in the same manner as at SRL. These results will be used to verify the accuracy of the reported radionuclide inventory. During initial radioactive operations in the DWPF, more frequent sampling of DWPF glass is likely in order to ensure that any phenomena dependent on the actual melter design and operation (e.g. volatilization) have been properly accounted for in the calculation of the radionuclide inventory.

Documentation

The Waste Form Qualification Report will include a report on the methods to be used to determine the radionuclide inventory during production, and the precision and accuracy of the methods used, based upon demonstrations in SRL's Shielded Cell Facility, and analyses of samples from the Tank Farm.

The Production Record for each canistered waste form will include estimates of the content of each radionuclide listed in Table 3.400.1. The values reported in the Production Records will either be measured or calculated values, depending on the particular radionuclide. However, the reported inventory for all radionuclides will be expressed as curies per unit mass of glass and will remain constant throughout the entire macro-batch.

References

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2. N. E. Bibler, "Leaching Fully Radioactive SRP Nuclear Waste Glass Tuff Ground-Water in Stainless Steel Vessels," **Advances in Ceramics - Nuclear Waste Management**, 8, W. A. Ross and G. G. Wicks (eds.), 619-626 (1986).

TABLE 3.400.1 Radionuclides to be Included in the Reported Radionuclide Inventory of DWPF Glass

RADIONUCLIDE	REASON FOR REPORTING
Ni-59	> 0.01 %, for all t > 400 years
Ni-63	> 0.01 %, for all t > 200 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

TABLE 3.400.2 Method of Determination of Content of Radionuclides to be Reported as the Radionuclide Inventory of DWPF Glass

RADIONUCLIDE	METHOD OF DETERMINATION
Ni-59	Calculate from Ni-63 analysis
Ni-63	Separation and β-counting
Se-79	Calculate from Sr-90 analysis
Sr-90	Separation and β-counting
Zr-93/Nb-93m	Calculate from Sr-90 analysis
Tc-99	Separation and β-counting
Pd-107	Calculate from Ru-106 analysis*
Sn-126	Calculate from Sb-126 analysis**
Cs-135	Calculate from Cs-137 analysis
Cs-137	γ-PHA
Sm-151	Calculate from Pm-147 analysis†
Th-230	Calculate from Pu-238 analysis
U-234	Calculate from Pu-238 analysis
U-238	Chemical analysis by ICP
Np-237	Separation and gross α-counting or α-PHA
Pu-238, Pu-239, Pu-240, Pu-241, Pu-242	Separation and mass spectrometry
Am-241	Separation and γ-PHA
Am-243	Calculate from Cm-244
Cm-244	Separation and mass spectrometry or α-PHA

* Ru-106 is determined by separation and γ-PHA

** Sb-126 is determined by separation and β-counting

† Pm-147 is determined by separation and β-counting

TABLE 3.400.3 Application of DWPF Methods to Determination of the Radionuclide Inventory of DWPF Glass

Radionuclide	Content (mCi/g glass)*
Sr-90	7.18 ± 0.68
Cs-137	0.111 ± 0.004
Eu-154	0.045 ± 0.009
Pu-238	0.042 ± 0.005
Eu-155	0.016 ± 0.001
Sb-125	0.0099 ± 0.0005
Co-60	0.0055 ± 0.0045
Zr-95	0.005

* Indicated range is average uncertainty. If no range is indicated, only a single determination was made.

FIGURE 3.400.1 Tasks planned to satisfy Specification 1.2.2, Radionuclide Inventory during Production

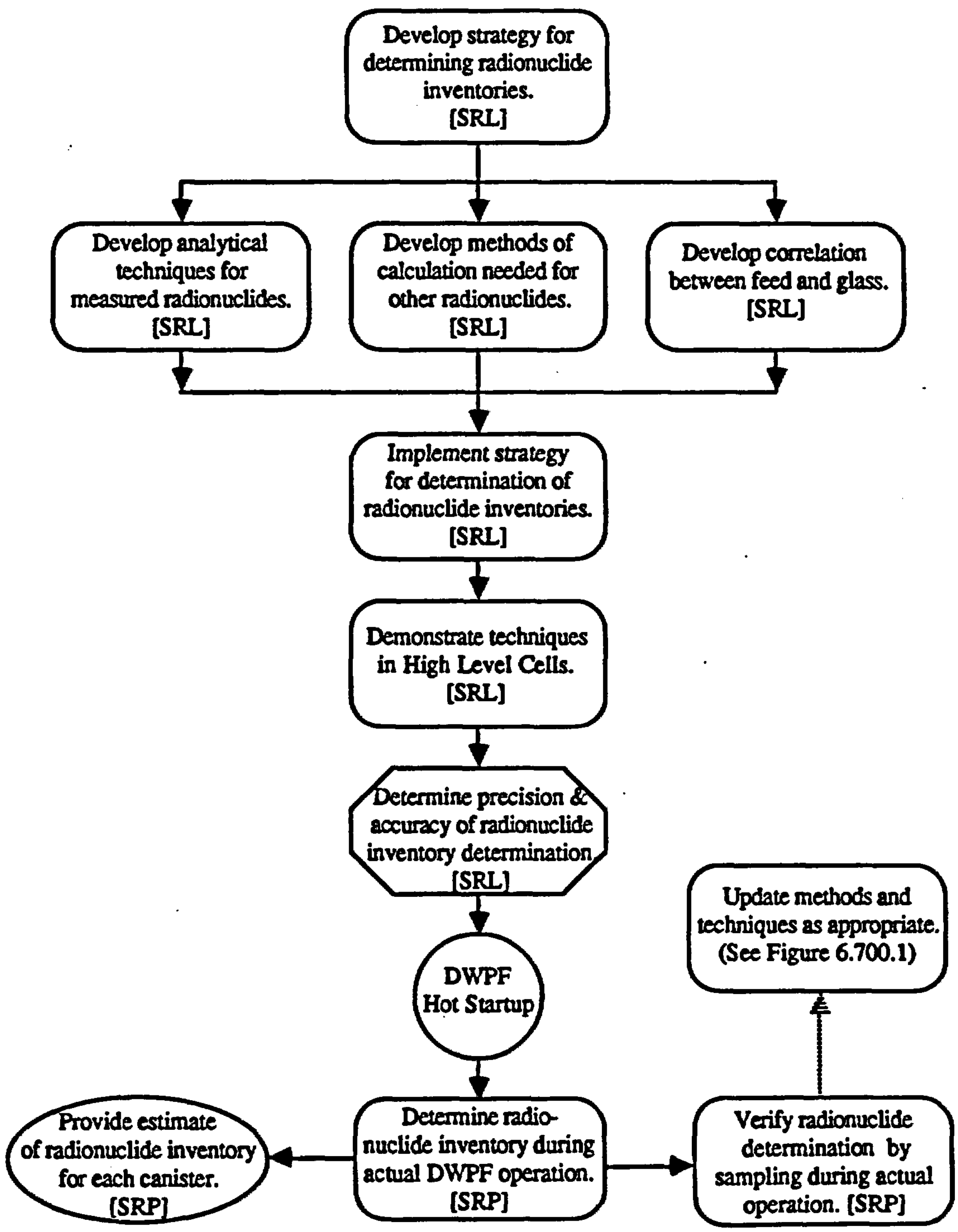
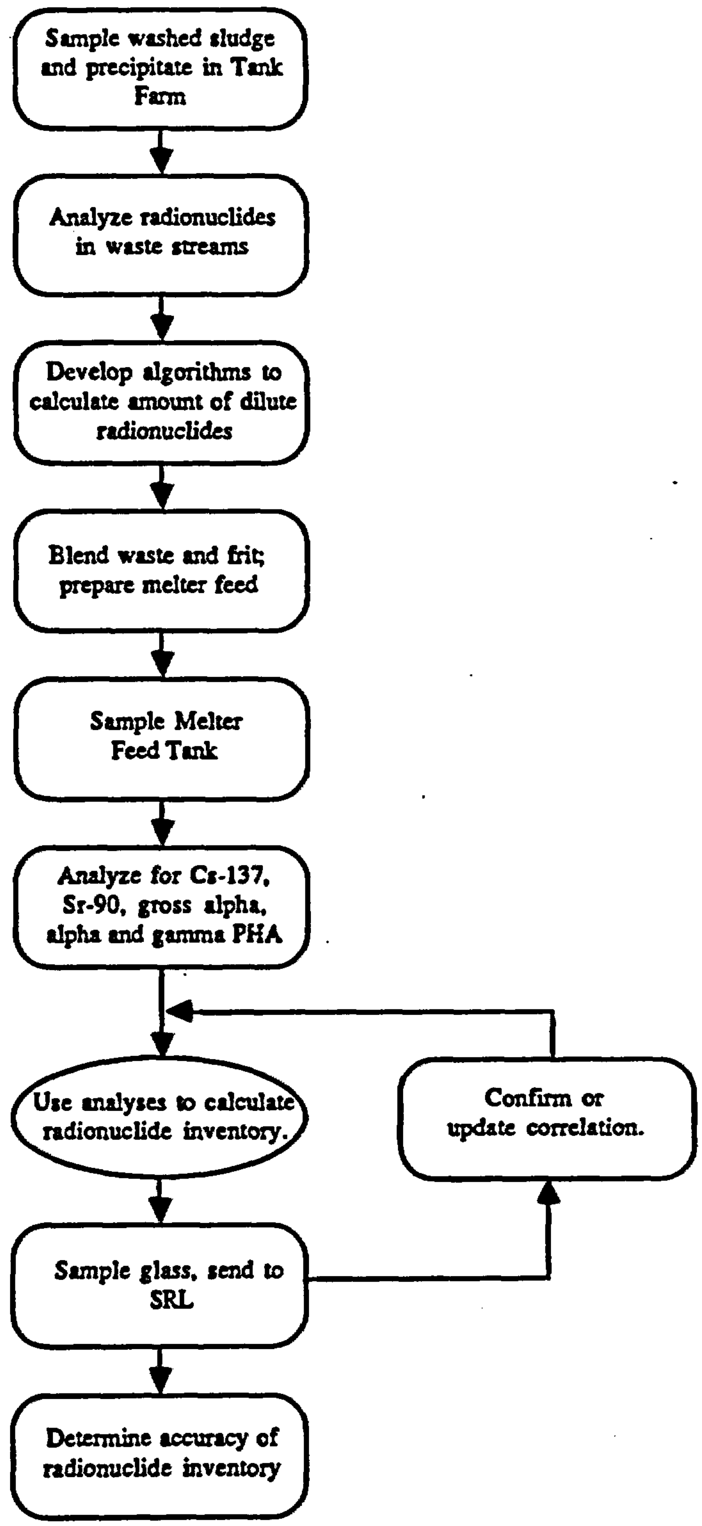


FIGURE 3.400.2 Strategy to Determine Radionuclide Inventory of DWPF Glass during Production



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3.1 CONTROL OF RADIONUCLIDE RELEASE PROPERTIES

1.3 SPECIFICATION FOR RADIONUCLIDE RELEASE PROPERTIES

The producer shall control the radionuclide release properties of the waste form during waste form production to satisfy the requirements of Specifications 1.3.1 and 1.3.2, or Specification 1.3.3. The producer shall describe the intended method for demonstrating compliance in the WCP. Supporting technical documentation for the selected method of control shall be included in the WQR. Documentation supporting the selected method of verification of compliance and the verification of results shall be included in the production records.

1.3.1 Control of Radionuclide Release Properties

For the Nevada Nuclear Waste Storage Investigations Project, the ability of the waste form to limit releases of radionuclides shall be demonstrated using test MCC-1 (Materials Characterization Center-1, Nuclear Waste Materials Handbook, DOE/TIC-11400, 1983) conducted in deionized water at 90°C. The test duration is to be 28 days. The acceptance criterion is that the normalized elemental leach rate for the matrix elements sodium, silicon, and boron, and for the radionuclides cesium-137 and uranium-238 shall be less than one gram per square meter per day averaged over the 28 day test duration.

1.3.3 Alternative Means of Compliance

The producer may use an alternative approach to demonstrate control of the radionuclide release properties of the waste form from that of Specifications 1.3.1 and 1.3.2 provided that the producer relates, to the satisfaction of the repository project, the radionuclide release properties of the waste form obtained using the alternative approach to those that would be obtained by adhering to the requirements of Specifications 1.3.1 and 1.3.2.

Rationale

The justification for this specification is the need for control of waste form release properties during production

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and the need for information concerning the release of radionuclides from the waste form that is based on or can be related to repository-site-specific release tests and sampling criteria. The repository-site-specific test procedures and the correlation of the data obtained using these test procedures with waste form release properties under repository conditions were developed to satisfy regulatory criteria. Both the Nuclear Regulatory Commission criteria (10 CFR 60) and the Environmental Protection Agency criteria (40 CFR 191) have defined long-term radionuclide release in terms of the engineered barrier system and the mined geologic disposal system respectively. As a component part of these systems, the waste form may be required to contribute to the compliance with these requirements. The preliminary allocation of performance requirements among the various components of the engineered barrier system and the repository system is to be described in repository Site Characterization Plans. Therefore, site-specific tests and sampling specifications are required.

Compliance Strategy

Borosilicate glass was chosen as the waste form for the DWPF because of its ability to retard the release of radionuclides. The DWPF will demonstrate that the entire range of expected glass compositions (see Part 3, Item 100) will meet this specification. At the present time, the only process variable which has been shown to affect the glass's ability to meet the specification is the chemical composition, as long as a vitrified product has been formed. The DWPF process will be controlled so that only feed which will produce acceptable glass will be delivered to the melter. As long as the melter is operated within the range of temperatures for which it is designed, delivery of a vitrified product to the canister is assured.

The MCC-1 procedure requires a test period of 28 days. Thus, it is not useful for direct control of the consistency of plant operations, because it would not allow adjustments of process parameters to be made in a timely enough manner to control the radionuclide release properties of the waste glass. For this reason, an indirect strategy of control has been developed for operation of the DWPF, as allowed by Specification 1.3.3.

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This strategy requires identification of those variables which significantly affect the radionuclide release properties of the glass, and then development and implementation of process controls to ensure that the DWPF consistently produces an acceptable product. For each variable which significantly affects the radionuclide release properties of the glass, the DWPF will describe the process control program for that variable in the WCP. The WQR will then contain the documentation demonstrating how well the variable is controlled. As noted above, the melter has been designed so that only vitrified material can be delivered to the canister. The control program for chemical composition is described below.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.500.1. The initial action was to identify potentially important variables for controlling radionuclide release properties. A test program has been planned which will determine the importance of these variables to glass radionuclide release properties. For those which are important to radionuclide release, appropriate controls will be developed. Control of radionuclide release will then be demonstrated in pilot plant operations, in laboratory tests with actual wastes, and during the DWPF Integrated Cold Run (see Appendix 1.200.2).

Identification of the variables potentially important to radionuclide release properties has been completed. These are sludge content and composition, precipitate hydrolysis product content and composition, frit composition and content, glass redox, glass melt temperature, glass pour temperature, and melter residence time.

A detailed program plan has been developed which will determine the effects of variations of these variables on glass properties, including radionuclide release properties. This program will vary each of these variables over a wide range. The effects of these variations on radionuclide release will be determined in laboratory scoping tests. Those variables found to have no significant effects will be discarded. In the second phase, tests performed using SRL's Research Melter will be used to relate the effects of

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these variables to DWPF operations. Although, as discussed below, plans have been made for the second phase of testing, these may be changed based upon the results of the initial scoping study.

The process variables cited above will be varied over the following ranges:

Sludge Content and Type: The Savannah River Plant has utilized both the HM and Purex reprocessing flowsheets. This has resulted in two types of sludges: high-aluminum and high-iron. The sludges are stored both separately and together resulting in a broad range of sludge blend compositions. The two extremes (high-iron and high-aluminum) will be used for scoping tests. The initial DWPF blend will be included in later tests using the Research Melter. The nominal sludge content of DWPF glass is 28 wt%. A range of 0 to 45 wt% will be used in the scoping study.

Precipitate Hydrolysis Product (PHP) Content: The composition of the soluble salt waste at SRP is expected to remain essentially constant during the life of the DWPF. Like the sludge ratio, variations in the PHP content (nominally 8 wt% oxide basis) will occur. The PHP content will be varied from 0 to 16 wt% for the scoping tests.

Frit Composition and Content: Most of the glass-forming additives to the sludge enter the feed as borosilicate glass frit, while the remainder enters as the PHP. Since nominally 64% of the glass content is frit, any variations in frit composition could result in glass properties outside the range of the set of reference glasses. However, pilot-plant experience over the last 10 years has shown that a combination of component specifications and verification testing will virtually eliminate variability in the feed due to variability of the frit.

Thus, for the purposes of these tests, the frit will not be varied independently, because variations in glass-former composition are more likely to come from variations in the amount or composition of PHP. The frit recommended for the initial DWPF sludge batch will be used for this test. The frit content will automatically be varied by changes in the amounts of the other two components in the melter feed.

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Glass Redox: In the DWPF, formic acid is added to reduce the valence states of multivalent species in the feed before melting (especially mercury). Variations in the amount of formic acid added are the most likely source of variations in the valence states of multivalent oxides in the glass. This test will investigate the range from 0 to twice the design-basis amount of formic acid.

Titanate Addition: The sodium titanate added to adsorb residual strontium and plutonium also offers a potential for a process batching error. This test will investigate the range from no titanate to twice the expected amount (i.e. double batching).

Melt Temperature: The nominal melt temperature is 1150°C. As the sludge content increases, the liquidus temperature of the glass also increases. Since the temperature varies throughout the melt, operation close to or below the liquidus temperature may affect the glass microstructure and has been shown to reduce the melt rate. Limited sub-liquidus testing will be conducted during the scoping study. Preliminary tests at temperatures well below the melter's design limits indicate that the ability to pour glass is strong evidence that the temperature of the melt has been sufficiently controlled.

The melt temperature will be varied from 1050°C to 1200°C in the Research Melter. The minimum melt temperature (1050°C) is based on the DWPF melter's minimum design temperature. The maximum melt temperature (1200°C) is based on limitations of the melter's materials of construction, particularly Inconel 690™.

Pour Temperature: The nominal pouring temperature is 1100°C. Because the pouring temperature can not be reliably varied during the scoping study or in the Research Melter tests, testing of its effects (if any) will be done in pilot plant equipment. However, pour temperature is not expected to affect the radionuclide release properties of the glass.

Melter Residence Time: The nominal residence time of the DWPF melter is 65 hours. Since residence time is largely a function of melter design (melt volume), low residence times are difficult to accomplish in continuously fed melters. The minimum time at temperature to dissolve the waste into the glass will be determined

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during crucible tests. Residence times as short as fifteen minutes will be used. Since the Research Melter residence time is at least a factor of 6 less than the DWPF residence time and expected to be at least a factor of 6 above the minimum required residence time, any residence time effects significant to DWPF operation should surface in the Research Melter tests. Research Melter tests will be limited to nominal values (about 12 hours).

The primary experimental response which will be used to determine the effects of the variables on radionuclide release properties is the DWPF Product Consistency Test (PCT), which has been developed by SRL (see Part 3, Item 550). The objective of the Product Consistency Test is to provide confirmation of the consistency of the DWPF product. The PCT procedure is

- Sensitive to glass composition and homogeneity.
- Reproducible and precise.
- Short in duration (7 days).
- Compatible with remote operation.

The PCT is an extraction procedure that requires little sample preparation. A detailed description of the PCT procedure may be found in Appendix 3.500.1. Tests at varying ratios of glass surface area to solution volume indicate that the results of this short-term test can be related to MCC-1 test results in a straightforward fashion.

Current evidence indicates that the radionuclide release properties of the DWPF product can best be controlled by controlling the chemical composition of the glass (as long as glass is made). This has been demonstrated both experimentally and theoretically. Experimentally, the reactivity of glasses typical of those to be produced in the DWPF have been shown to be affected very little by variations in parameters such as residence time, the size of the melter, or crystalline content of the glass.[1-3] 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.[4-9] Theoretically, the hydration thermodynamic ap-

proach,[10-12] originally developed to explain differences in durability of ancient glasses, leads to the prediction that the long-term durability of glass should depend most strongly on the chemical composition of the glass, and very little on other process parameters.

In Figure 3.500.2, the free energy of hydration calculated from the glass composition is plotted against the extent of reaction between glass and water, represented by the silicon release in a 28-day MCC-1 leach test. As can be seen from the figure, the reactivity of the glass toward water is strongly dependent on the glass composition. These glasses represent a wide range of synthetic and natural silicate glass systems, produced under both controlled and uncontrolled conditions. Also shown on the figure are the limit prescribed in Specification 1.3.1, and the anticipated performance of the range of glasses to be produced in the DWPF. The excellent correlation over four orders of magnitude of the extent of reaction with glass composition is evidence of the relative unimportance of other process parameters. In any event, the program outlined above will firmly establish the significance of all of the process variables tested.

The elements of the process control program for glass chemical composition include sampling, measurement, adjustment and confirmation. Samples from the last feed preparation vessel in the DWPF, the Slurry Mix Evaporator (SME), will be taken using the sampler shown in Figure 3.200.3. The precision and accuracy of sampling should be the same as that for the Melter Feed Tank samples (Part 3, Item 200), because the materials are chemically and physically identical. Measurement techniques will be the same as those described for Melter Feed Tank samples (Part 3, Item 200). The control limits as far as the Waste Acceptance Process are concerned are that the glass composition must be within the range of compositions projected for the DWPF product as described in Part 3, Item 100. If the composition of the material in the Slurry Mix Evaporator will not produce glass within that composition range, the material will be held, and additional chemicals added to the SME. The SME is equipped with cold feed lines which will allow additional flexibility if chemical additions are necessary.

If adjustments are made, the SME material will be re-sampled and

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analyzed again to confirm that the SME material has been brought within control limits. Transfer of material to the Melter Feed Tank will only be allowed when it has been determined that the SME material is within control limits. Samples will be taken from the Melter Feed Tank to provide verification of control of the chemical composition (See Part 3, Item 550).

Documentation

The Waste Form Qualification Report will include a report which will identify the important variables for radionuclide release, and describe the methods to be used for controlling these variables. The accuracy and precision of the methods of control will also be reported. The Waste Form Qualification Report will also include the results of demonstrating the control of glass durability (as measured by the PCT) during the DWPF Integrated Cold Run, and will relate the results of the PCT to the MCC-1 test.

The process variable of greatest importance to the radionuclide release properties of DWPF glass is its chemical composition. This will be reported in the Production Records as described in Part 3, Item 200. The values of any other process parameters which are found to significantly affect the radionuclide release properties of DWPF glass will also be reported in the Production Records.

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McVay (ed.), 755-62 (1985).

FIGURE 3.500.1 Tasks planned to satisfy Specification 1.3.1, Control of Radionuclide Release Properties

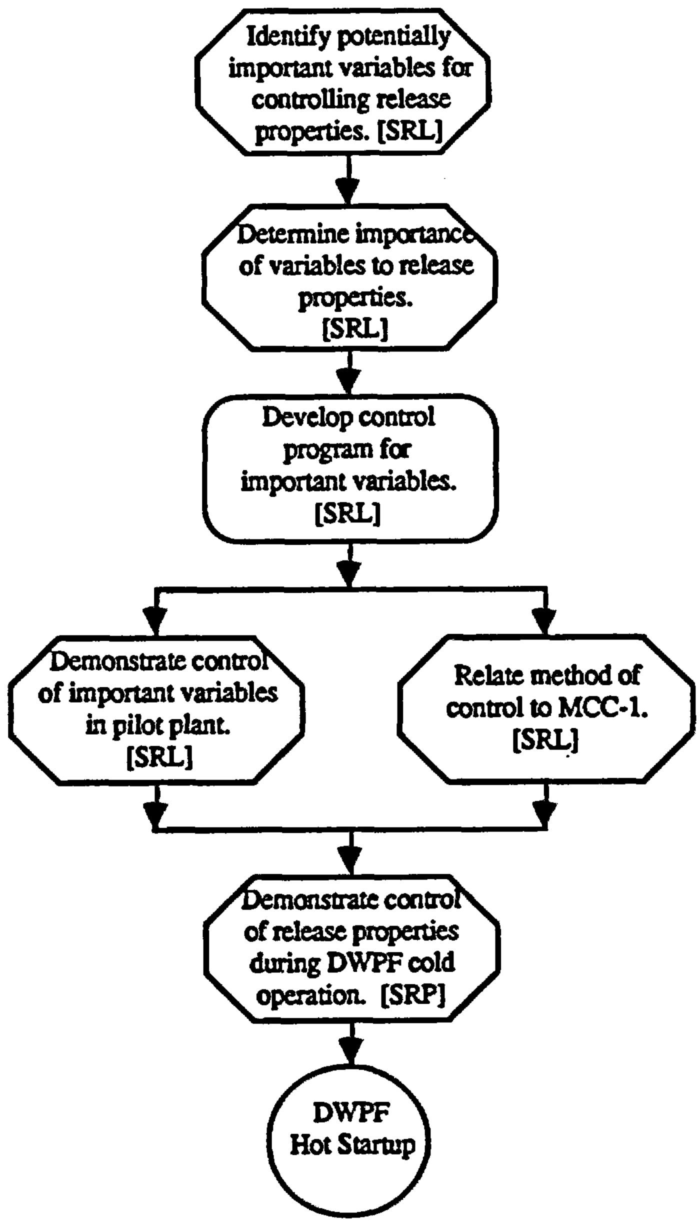
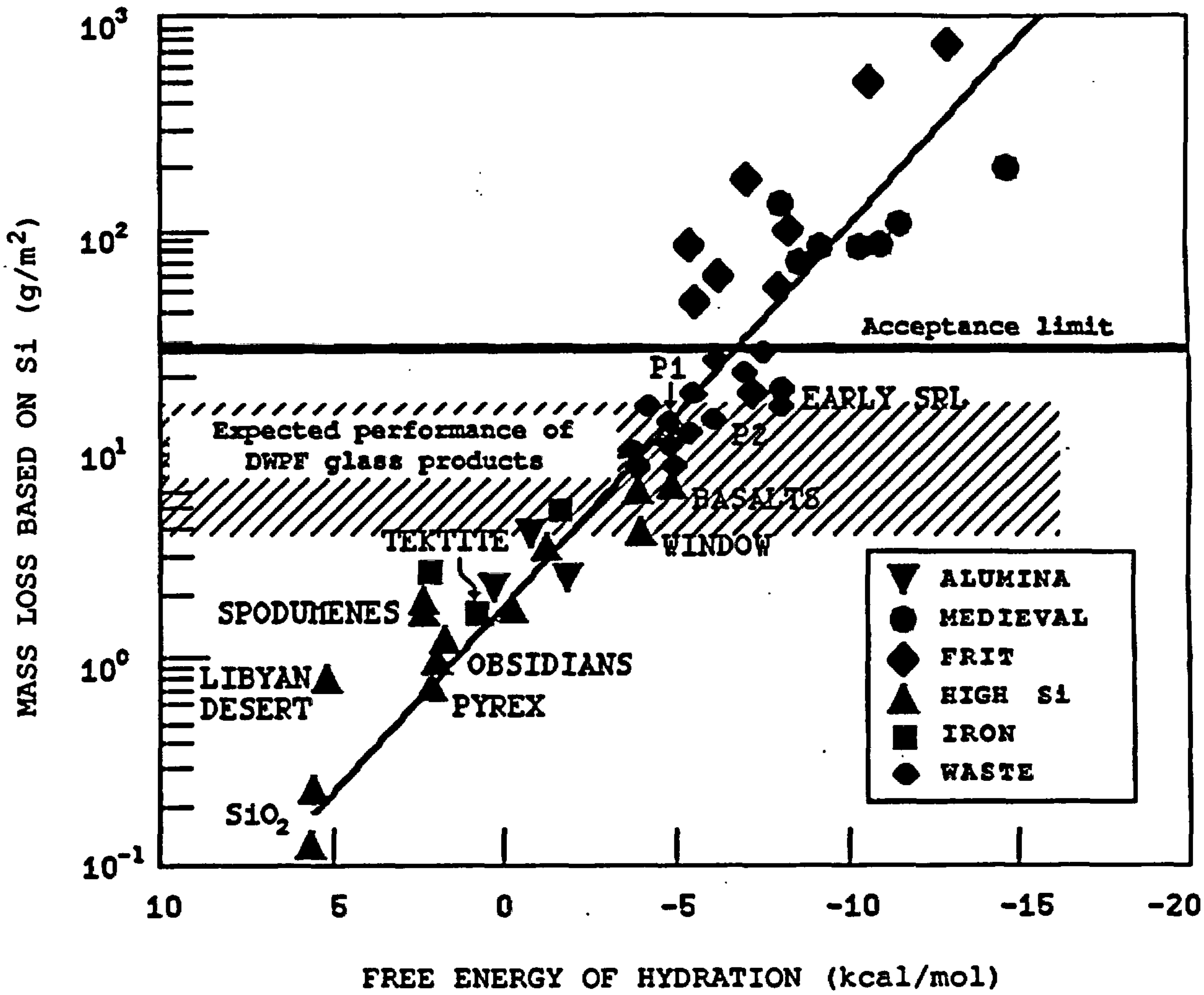


FIGURE 3.500.2 Effect of glass composition on reactivity of glass with water



MCC-1 test results - glass exposed to deionized water for 28 days, at 90°C.

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1.3.2 Verification of Radionuclide Release Properties

The capability of the waste form to meet this specification shall be demonstrated by testing actual production samples of waste forms. The sampling schedule shall be sufficient to demonstrate at the 95 percent confidence level that 95 percent of the production waste forms would yield leach test results that conform to the criterion. Test samples shall be taken from a convenient location near the mouth of the waste form canister before the canister is sealed closed. The temperature of the waste form at the time of sampling shall be no higher than 90°C.

1.3.3 Alternative Means of Compliance

The producer may use an alternative approach to demonstrate control of the radionuclide release properties of the waste form from that of Specifications 1.3.1 and 1.3.2 provided that the producer relates, to the satisfaction of the repository project, the radionuclide release properties of the waste form obtained using the alternative approach to those that would be obtained by adhering to the requirements of Specifications 1.3.1 and 1.3.2.

Rationale

Specification 1.3.3 provides the producer with the flexibility to employ an approach to demonstrate control of the radionuclide release properties of the waste form that is different from that of Specifications 1.3.1 and 1.3.2 in recognition that another approach may better lend itself to the producer's waste form production process. The producer must demonstrate the relationship between the results obtained from any alternative approach and those which would be obtained by adhering to the requirements of Specifications 1.3.1 and 1.3.2 to provide assurance that the radionuclide release specification will be met.

Compliance Strategy

As discussed in the compliance strategy for Specification 1.3.1 (Part 3, Item 500), the radionuclide release properties of the

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waste glass will be controlled by controlling the variables that are determined to be important in affecting the radionuclide release properties of the glass. During production of canistered waste forms, the DWPF will verify radionuclide release properties by verifying that the parameters used to control glass durability were actually within control limits. Development of a correlation between the control variables and the results of the MCC-1 test will be an important part of this strategy. Samples of glass will be taken periodically, and tested to provide additional confirmation of control. The DWPF's Product Consistency Test will be utilized for this purpose.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.550.1. The initial action is to develop a strategy for verification of radionuclide release properties during production. As noted in Part 3, Item 500, an indirect strategy will be used to control the radionuclide release properties of the DWPF product. The primary form of verification will thus be demonstration that process variables of importance to the radionuclide release properties (such as chemical composition) of the glass have been maintained within control limits.

At this time, the only process variable which has been shown to be of importance to the radionuclide release properties of the glass is the chemical composition. Control of glass composition is discussed in Part 3, Item 500. The point of control is the last feed preparation vessel, the Slurry Mix Evaporator. The primary verification of the chemical composition of the glass will be by analysis of samples from the Melter Feed Tank. Sampling and analytical methods, and the anticipated precision and accuracy, have been discussed in Part 3, Item 200.

During the Integrated Cold Runs, samples of feed and glass will be taken to verify the feed composition-glass composition correlation developed from laboratory and pilot plant tests. If deviations from this correlation are detected, the correlation will be modified to be consistent with the test results..

Some additional confirmation using glass samples taken from the pouring glass stream is also planned during routine DWPF opera-

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ITEM TITLE: 1.3.2 VERIFICATION OF RADIONUCLIDE RELEASE PROPERTIES

tions with radioactive waste. When glass samples are taken in the DWPF, they will be sent to SRL for chemical and radiochemical analyses. At least one glass sample representative of each macro-batch will be taken (1 every 3 or 4 months) to confirm that the glass composition is within control limits. In the case of the chemical composition, these limits are the reference glass compositions which will be provided as described in Part 3, Item 100.

A statistical technique is under development at the present time which will be used to define the necessary sampling frequency for each macro-batch. It also will be used to determine the confidence level of both the analytical results and the feed-glass correlation. Using the combination of glass samples and the feed-glass correlation, the DWPF will demonstrate that the radionuclide release properties of the glass have been controlled to at least the 95% confidence level.

The sampling regimen prescribed in Specification 1.3.2 is not compatible with the DWPF process and product. A glass sampler, suitable for routine DWPF use, has been developed and tested. Approximately 50 g of glass will be taken from the flowing stream of molten glass as it is poured from the melter into the canister. The reference design is shown in Figure 3.550.2.

The MCC-1 test, because it requires monolithic samples, is not suitable for samples of glass taken during production. These samples will not be annealed, and thus cannot be reliably cut into monoliths. For this reason, the DWPF has developed an alternative leach test procedure (the Product Consistency Test - see Appendix 3.500.1) which is suitable for the DWPF product. As called for in Specification 1.3.3, the results of this test will be related to results from the MCC-1 test.

A portion of each glass sample taken will be tested with the PCT. This will provide additional assurance that all of the process variables have been controlled so that the radionuclide release properties of actual DWPF glass are consistent with those used for testing for the Waste Form Qualification Report.

If other process variables are found to have an effect on radionuclide release properties of DWPF glass (See Part 3, Item 500), strategies for their control and verification will be developed.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.3.2 VERIFICATION OF RADIONUCLIDE RELEASE PROPERTIES

These strategies will then be documented in the Waste Form Compliance Plan.

The methods of control will be related to the results of the MCC-1 test. The entire control and verification strategy will be demonstrated during the DWPF Integrated Cold Runs (see Appendix 1.200.2). In particular, it will be demonstrated that glass samples taken with the reference sampler are representative of the canister contents.

Documentation

The Waste Form Qualification Report will include a report on the methods to be used for verifying the radionuclide release properties of the waste glass during production. Supporting information for these methods will also be included.

The Production Record for each canistered waste form will include a record of the parameters which verify control of the radionuclide release properties. Thus, the Production Records will document that the chemical composition of the glass produced is within the range of projected compositions (as noted above), and will provide evidence that any other property which affects the ability of the glass to retain radionuclides has been controlled (At the present time, the chemical composition is the only property which has been shown to affect the ability of the glass to retain radionuclides.). In addition, the results of analysis and testing of glass samples from each macro-batch will be included in the Production Records as an Addendum.

FIGURE 3.550.1 Tasks planned to satisfy Specification 1.3.2, Verification of Radionuclide Release Properties

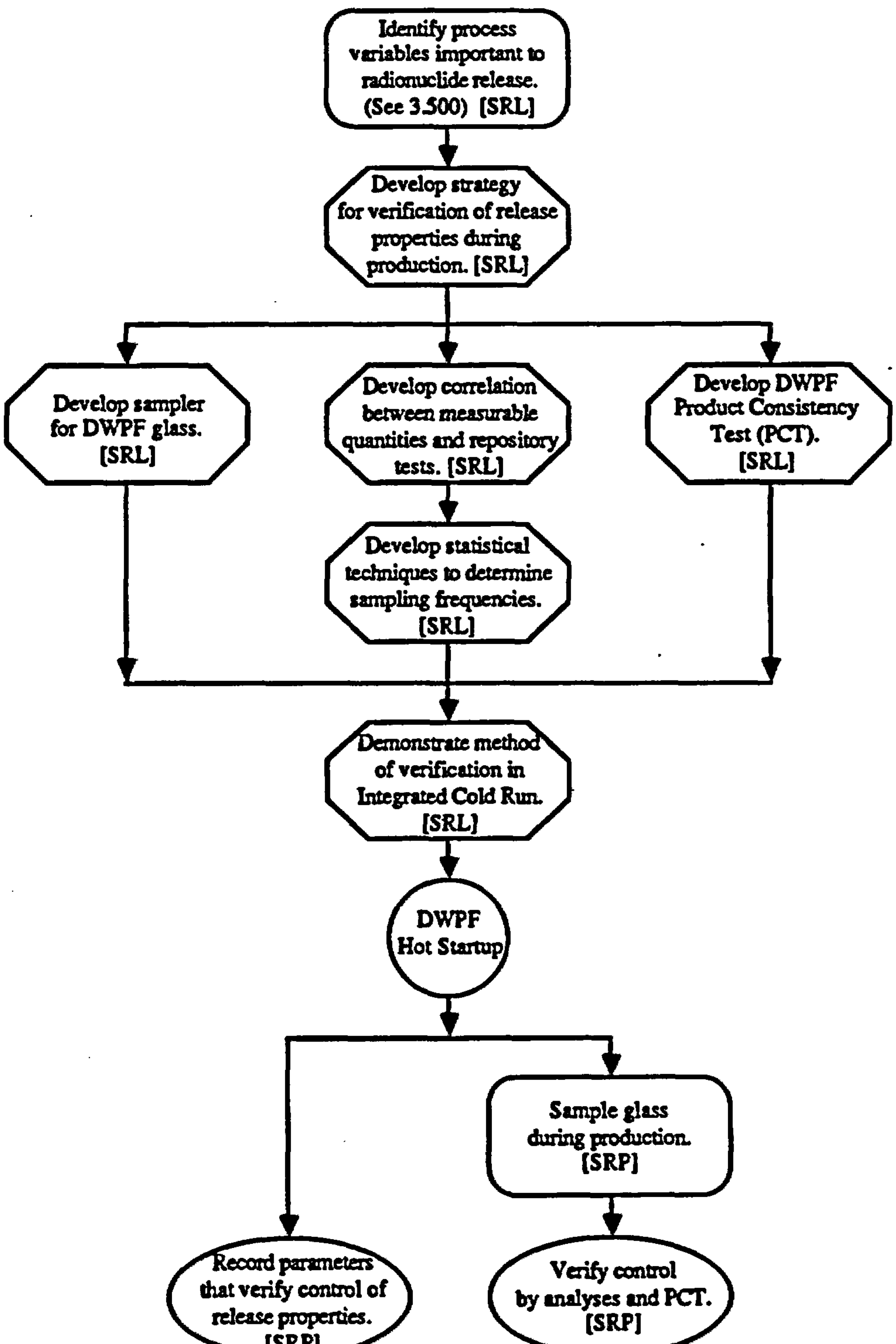
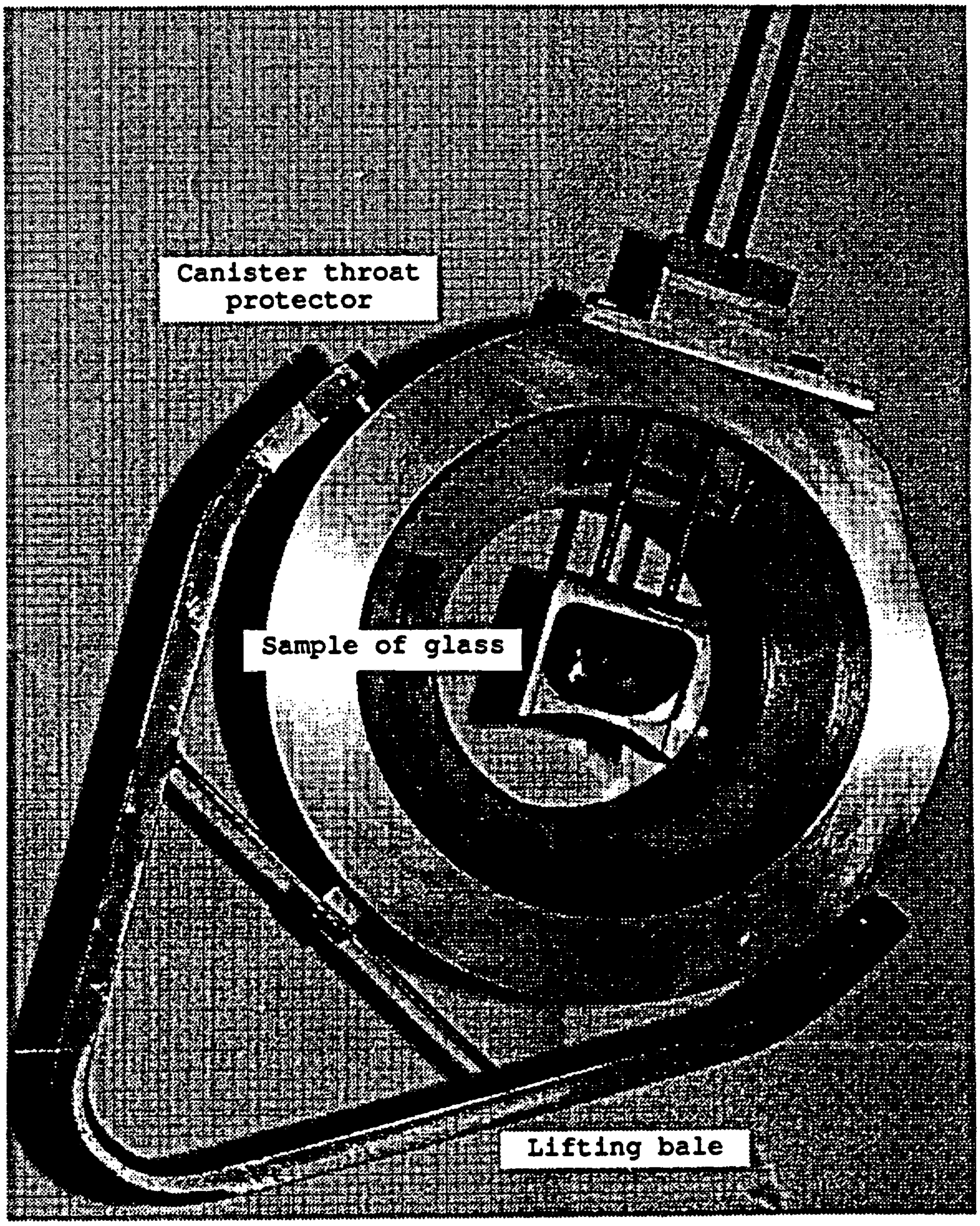


FIGURE 3.550.2 Reference DWPF glass sampler



PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

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

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

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

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

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

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

Rationale

Specifications 1.4.(a) and 1.4.(b) will provide data useful to the repository project for establishment of repository and waste package design limits. The certifications required will provide assurance that producers and transporters have not handled or stored the wastes in such a way as to cause significant changes in the phase structure. The available evidence indicates that the borosilicate glass waste forms will retain release properties similar to those obtained under Specification 1.3 so long as the phase structures and compositions of the glass are unchanged from those provided under Specification 1.1. The evidence also indicates that:

- Neither energy input nor radioactive decay significantly affect radionuclide release from waste glass, as long as the temperature of the glass does not exceed the glass transition temperature (approximately 500°C). Above this temperature, significant changes in phase composition can occur.

- For glasses of the type that will be produced by DWPF, even changes in phase composition due to devitrification do not greatly alter the rate of release of material from the glass.

A program has been and continues to be in place to ensure that the effects of energy input and radioactive decay on glass properties are well-understood.

The requirement for certification of conditions during transportation has been included herein to identify the need for consideration of these requirements during design of the transportation system. Certification of conditions during transportation will be the responsibility of the transporter, not the producer.

Compliance Strategy

The transition temperatures and time-temperature transformation (TTT) diagrams will be determined for the reference glass composi-

tions described in Part 3, Item 100. Standard dilatometric and/or thermal analyses will be used to determine transition temperatures. Time-temperature transformation (TTT) diagrams will be developed using methods previously employed by researchers at SRL.[1-3]

Because the repository-specific radionuclide release tests have not yet been specified, SRL will use the same test developed for product consistency verification (PCT) to determine which combinations of time and temperature most affect glass product consistency. These extreme cases will then be tested using the repository-specific radionuclide release test(s) when available. In order to provide reasonable assurance of the acceptability of the glass before the DWPF begins radioactive operations, it will be necessary to perform most of the testing program using the PCT, rather than wait for the repository tests.

Transportation is not the responsibility of the DWPF, as is indicated in the WAPS Rationale; DOE-RW has assumed responsibility for transportation of the canistered waste form to a federal repository. The DWPF anticipates that the Waste Acceptance Preliminary Specifications will be changed to reflect this.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 3.600.1. Once the reference glass compositions in Part 3, Item 100, have been identified, the glass transformation temperature, T_g, of each of the reference glasses will be determined. 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 temperature does not depend very strongly on composition. If, as is currently believed, the glasses listed in Table 3.600.1 span the entire range of compositions of the DWPF canistered waste forms, then the glass transition temperature of a DWPF glass will be in the range from 440 - 460°C.

After filling, the temperatures of the canistered waste forms will not be routinely monitored in the DWPF. However, the canister surface temperature will be checked before it is inserted in the Canister Decontamination Chamber (CDC). The canister temperature must be below 100°C, prior to canister decontamination, to prevent steam generation. This transfer from the Melt Cell to the CDC

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

provides a convenient definition of the end of cooling after filling.

Calculations previously performed[4,5] have shown that free-standing DWPF canistered waste forms will not exceed the specified temperature (≥ 440°C) even at heat loadings 2-3 times higher than expected for DWPF glass (see Table 3.600.2; the design-basis heat loading is 690 watts). Thus, it is not possible to exceed the specified temperature limit in the vitrification building after cooldown is completed because the canisters are essentially free-standing in ambient air.

The canisters will be transported from the vitrification building to an interim storage facility. Here, they can no longer be considered as free-standing objects in ambient air. The DWPF storage facility for the canistered waste forms has been designed so that the maximum temperature of the canistered waste forms shall not exceed the glass transformation temperature. Calculations to establish this will be provided in the Preliminary WQR.

An analysis of the design of the initial interim storage facility will be performed to establish that the glass cannot reach or exceed the expected transformation temperature, T_g. The lowest expected glass transformation temperature is approximately 440°C. Initial estimates of the temperature during storage indicate that canister heat loads of greater than 5 kilowatts (> 5X the maximum projected heat generation rate of DWPF canistered waste forms) would be necessary to exceed 440°C during storage.

Time-temperature transformation diagrams for each of the reference glasses will be developed. The effects of changes of phase composition on radionuclide release will be determined as follows. For each of the time/temperature conditions used to develop the TTT diagram for each of the reference glasses, the DWPF Product Consistency Test (see below, and Appendix 3.500.1) will be performed. This will be used to determine which set of conditions most affect radionuclide release. When the repository-specific radionuclide release tests are available, they will be used to test these extreme cases as well as a few cases representing initial feeds and expected thermal conditions for the DWPF product.

Correlations of TTT diagrams with waste composition for specific

frit compositions have already been performed. In general, it has been found that the DWPFglass's durability is not strongly dependent on sludge composition, or on crystalline content.[6,7]

The Product Consistency Test (PCT), has been developed to provide confirmation of the consistency of DWPF glass. The PCT procedure is

- Sensitive to glass composition and homogeneity.
- Reproducible and precise.
- Short in duration (7 days).
- Compatible with remote operation.

The PCT is an extraction procedure that requires little sample preparation, and is proving to be very reproducible. A detailed description of the PCT procedure, and its development, may be found in Appendix 3.500.1. Tests in groundwaters, and at varying ratios of glass surface area to solution volume, indicate that the results of this short-term test can be related to repository-specific tests.

Documentation

The Waste Form Qualification Report will include the glass transition temperatures of the reference glasses. The WQR will also include time-temperature transformation diagrams for the reference glasses, and radionuclide release properties for representative glass samples, as described above. It will also include the complete set of results using the PCT test. The relationships between the SRL test and the repository-specific tests will be reported.

The Production Record for each canistered waste form will certify that the maximum waste glass temperature is at least 100°C below the transition temperature. The Production Record for each canistered waste form will also certify that, after initial cooldown and during storage at the DWPF, no unusual events occurred which would cause the maximum temperature of the canistered waste form to exceed the transition temperature.

PART TITLE: WASTE FORM SPECIFICATIONS

ITEM TITLE: 1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

References

1. 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).

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. 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 19808 (1983).

5. 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).

6. 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).

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

TABLE 3.600.1 Glass Transition Temperatures for SRL Simulated Waste Glasses

Composition*	Glass Transition Temperature (°C)
Design-basis glass	459
165/High iron waste	448
165/High aluminum waste	451
131/blended waste	460

*131 and 165 refer to glass-former compositions used by SRL. High iron and high aluminum refer to two possible extreme sludge compositions.

TABLE 3.600.2 Temperatures of Free-Standing Canisters

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

*Design-basis DWPF canistered waste form

FIGURE 3.600.1 Tasks sufficient to satisfy Specification 1.4, Specification for Chemical and Phase Stability

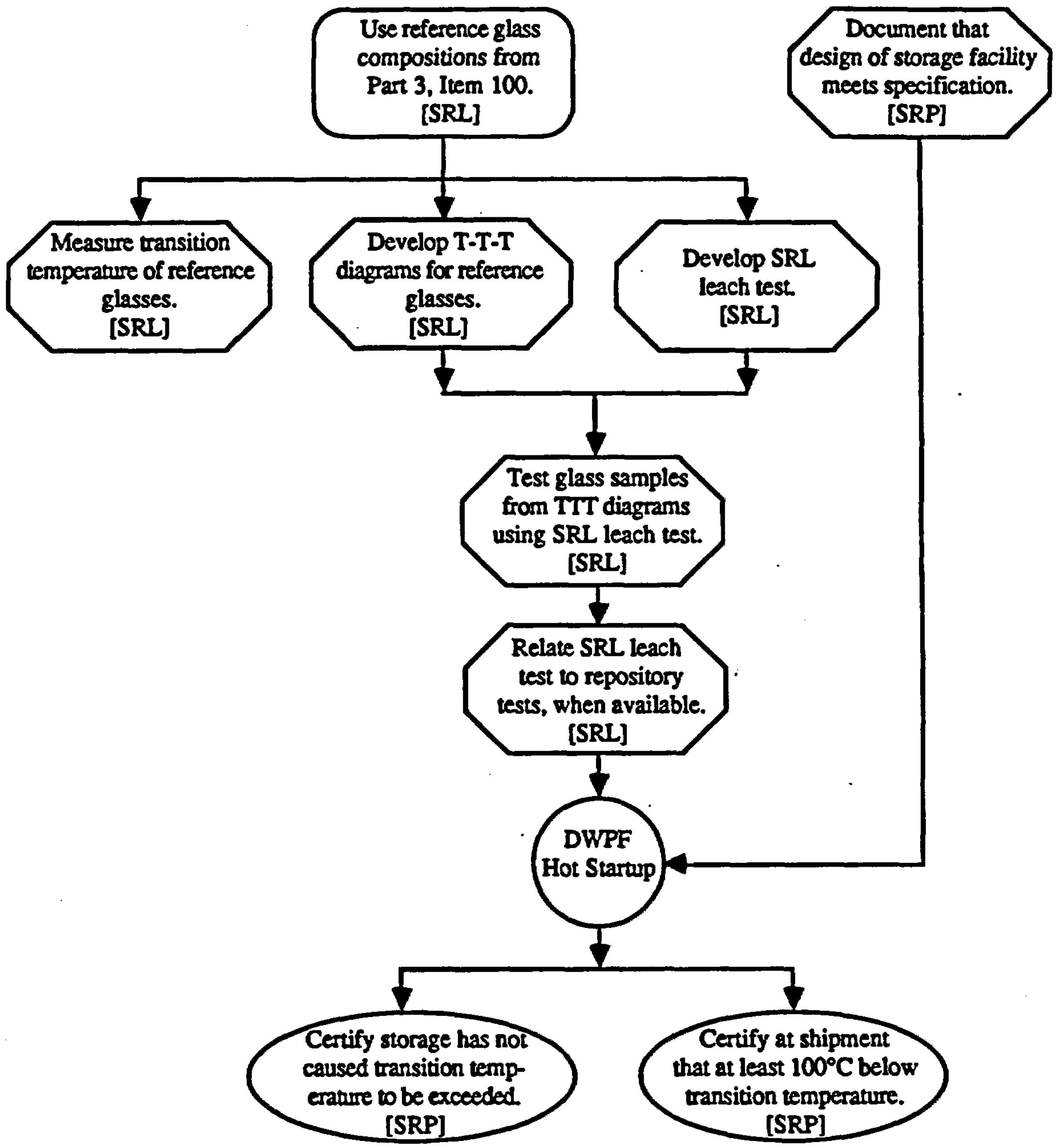
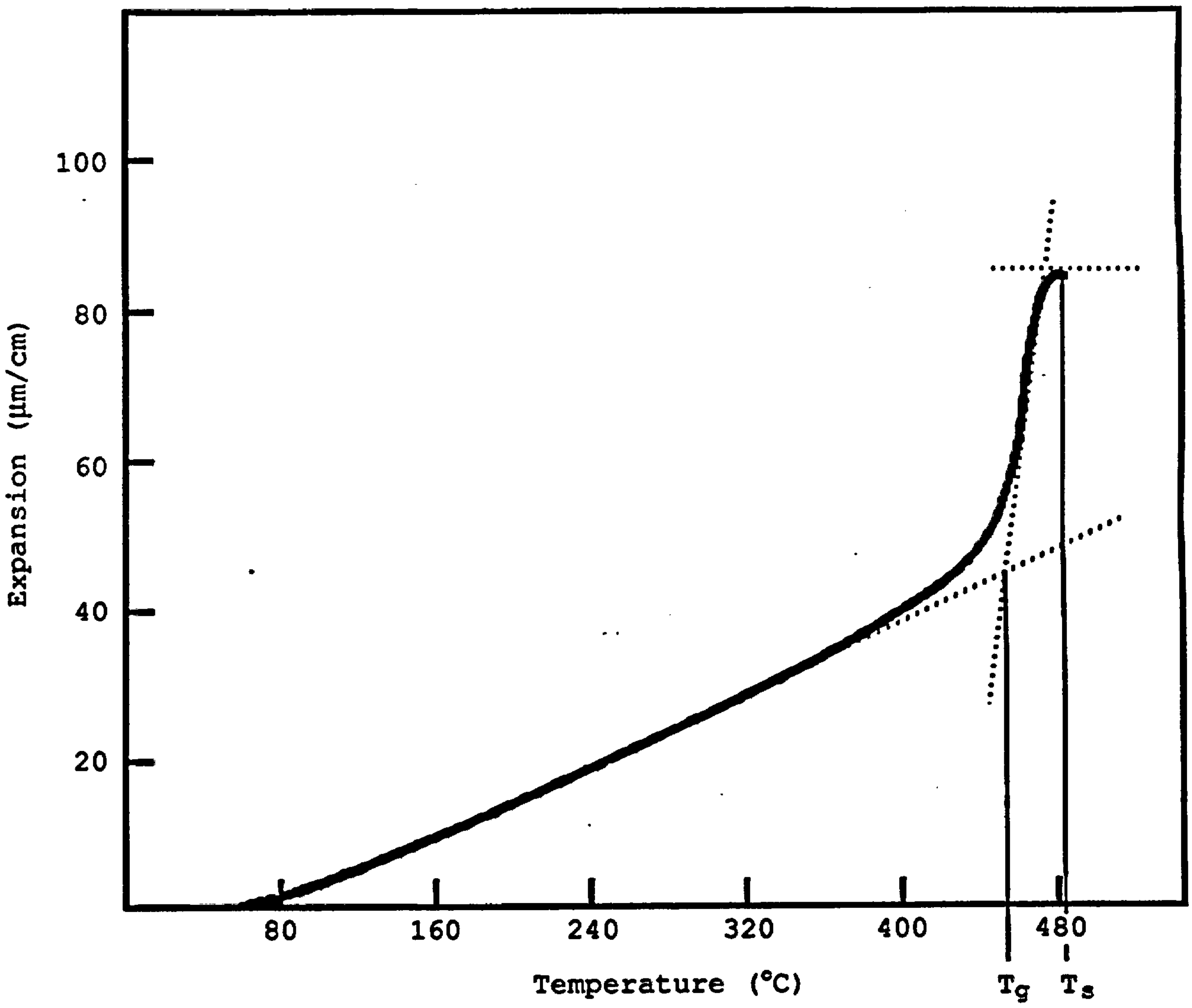


FIGURE 3.600.2 Dilatometric Determination of T_g for design-basis DWPF glass.



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

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.1 MATERIAL SPECIFICATION

2.1 MATERIAL SPECIFICATION

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

Rationale

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

Compliance Strategy

Assurance that the materials in the procured canister assembly meet the specification will be provided through a combination of component specifications, and inspections to ensure that specifications are met. Procurement documents for the DWPF canisters require that all material used in fabrication of the canisters shall meet the compositional requirements of the ASTM designations. The procurement documents also require that material certifications be provided to DWPF for each lot and heat used. The canisters are to be inspected by a Quality Assurance Field Representative (QAFR)

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ITEM TITLE: 2.1 MATERIAL SPECIFICATION

prior to shipment to DWPF. This inspection includes verification of documentation on the compositions of materials used during fabrication of the canister.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 4.100.1. The initial action, now completed, to satisfy this specification is to specify the required materials in the canister procurement documents. The current procurement specifications for the canisters designate the following materials.

Cylinder	ASTM A240 or A312 Type 304L stainless steel
Nozzle	ASTM A336 Type F304L stainless steel
Taper Plug	ASTM A240 Type F304L stainless steel
Neck Sleeve	ASTM A479 Type S21800 stainless steel (Nitronic 60)
Heads	ASTM A240 or A312 Type 304L stainless steel
Weld Plug	ASTM A240 Type 304L stainless steel
Repair Plug	ASTM A479 Type S21800 stainless steel (Nitronic 60)
Filler Metal for Welding	ASTM A336 Type F308L stainless steel

The alloy compositions corresponding to these speicifications are given in Tables 4.100.1 to 4.100.5. Canisters used in non-radioactive equipment development and testing at SRL have been procured to these specifications.

At the present time, the DWPF is assessing the need for a secondary canister. If 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 WCP. Any secondary canister would require use of the same materials specified above.

The DWPF is also assessing the usage of cast, rather than wrought,

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ITEM TITLE: 2.1 MATERIAL SPECIFICATION

alloys for fill canisters. Corrosion and drop testing of cast canisters filled with simulated waste glass has shown no adverse affects of this potential change on canister performance. If the DWPF concludes that cast alloys are acceptable, the chemical composition specifications for the canister materials will be broadened to include the equivalent compositional requirements for cast alloys.

Documentation

The WAPS require that the DWPF certify that the canister materials were the same as those specified in the Waste Form Compliance Plan. The Production Records will reference the procurement documents for the canister. The detailed procurement documents will include the actual specifications, purchase orders, vendor and heat identification records, certificates of analyses, and inspection records. Records of spot inspections performed at Savannah River, for example to verify that alloy composition meets specifications, will also be cited in the Production Records. Nonconforming canisters will not be accepted for DWPF use.

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	N 0.10 maximum

Reference: **Annual Book of ASTM Standards, 1.03,** American Society for Testing and Materials, Easton, MD, 62 (1987).

TABLE 4.100.2 Required chemical composition of ASTM A312 Type 304L stainless steel

Component	Amount (wt%)
Carbon	0.035 maximum
Manganese	2.00 maximum
Phosphorus	0.040 maximum
Sulfur	0.030 maximum
Silicon	0.75 maximum
Chromium	18.00 - 20.00
Nickel	8.00 - 13.00
Other elements	No specification
Reference:	**Annual Book of ASTM Standards, 1.01,** American Society for Testing and Materials, Easton, MD, 256 (1987).

TABLE 4.100.3 Required chemical composition of ASTM A336 Type F304L stainless steel

Component	Amount (wt%)
Carbon	0.035 maximum
Manganese	2.00 maximum
Phosphorus	0.040 maximum
Sulfur	0.030 maximum
Silicon	1.00 maximum
Chromium	18.00 - 20.00
Nickel	8.00 - 13.00
Other elements	No specification

Reference: **Annual Book of ASTM Standards, 1.05,** American Society for Testing and Materials, Easton, MD, 259 (1987).

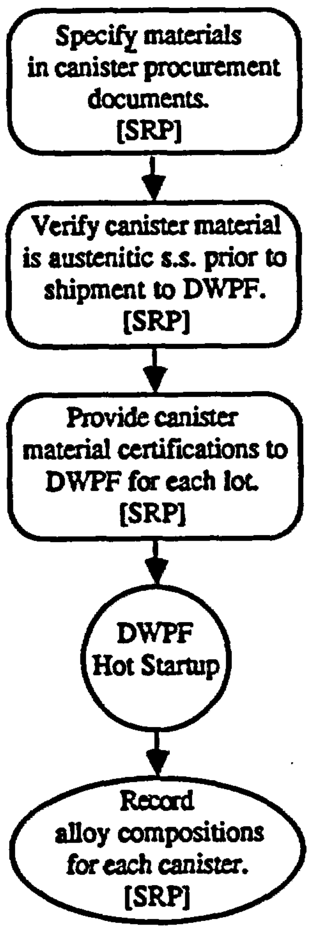
TABLE 4.100.4 Required chemical composition of ASTM A479 Type S21800 stainless steel (Nitronic 60)

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	N 0.08 - 0.18
Reference:	**Annual Book of ASTM Standards, 1.04**, American Society for Testing and Materials, Easton, MD, 361 (1987).

TABLE 4.100.5 Required chemical composition of ASTM A336 Type 308L stainless steel

Component	Amount (wt%)
Carbon	0.08 maximum
Manganese	2.00 maximum
Phosphorus	0.045 maximum
Sulfur	0.030 maximum
Silicon	1.00 maximum
Chromium	19.00 - 21.00
Nickel	10.00 - 12.00
Other elements	No specification
Reference:	**Annual Book of ASTM Standards, 1.03**, American Society for Testing and Materials, Easton, MD, 391 (1987).

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

Rationale

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

Compliance Strategy

The objective of this specification is to ensure that the canister will prevent water from contacting the waste glass until the DWPF canistered waste form is placed inside the waste package at a federal repository. The integrity of the canister itself will be ensured by specifications on the components of the canister, and on the method of fabrication of the entire canister. A rigorous program of inspection and verification will be applied to assure that these specifications are met. The integrity of the final closure weld applied in the DWPF will be assured by close control of the welding process, and inspection of the weld after closure.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 4.200.1. As shown in Figure 4.200.2, the canister is fabricated from a cylinder of standard 24 in.-outside diameter 304L stainless steel pipe, a dished bottom, a domed head, and a head nozzle containing a combined lifting and welding flange. These

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

components are welded together to form a canister 9 ft 10 in (300 cm) high, with a nominal wall thickness of 3/8 in.

One of the initial actions taken to satisfy this specification was to develop specifications for procurement of the DWPF canister. The materials specifications for the canister components are discussed in Part 4, Item 100.

The main cylinder is to be hot-rolled, annealed, and pickled 24 in.-outer diameter pipe. Canister heads and bottoms are to be hot-rolled, annealed, and pickled, and then cold formed into shape, then solution annealed, and reformed in the same die. The tapered plug and the Nitronic 60 sleeve are both to be machined to tolerances. Inspection frequency for each component is detailed in the canister specification.

The components are then to be welded together. 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 1983 Addenda - Welding and Brazing Qualifications, 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 the DWPF will approve all weld procedures prior to fabrication. A DWPF Quality Assurance Field Representative (QAFR) will verify that the procedures have been followed by inspections conducted at the vendor shop.

After fabrication, all welds will be subjected to a liquid penetrant examination per ASME Section V. Evaluation will be in accordance with Appendix 8 of ASME Section VIII. All full penetration butt welds will be subjected to a radiographic examination per ASME Section V. Evaluation will be in accordance with UW-51 of ASME Section VIII.

Each canister will be He leak tested. Only canisters with leak rates less than 1×10^{-7} atm·cc/sec will be acceptable. Each canister will also be pressure tested at 225 psi. The canister procurement specifications and inspection procedures will be documented in the Waste Form Qualification Report.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

The other action taken to satisfy this specification was to develop resistance welding 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, thermit, electron beam, laser beam and friction welding. Resistance welding was selected because of its reliable high weld quality, and its relatively simple equipment needs.[1]

In this process, a 5-in.-diameter, 1/2-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-levelling 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 70,000 lb., and a current of 230,000 amps at 10 volts, for 1.5 seconds.

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 5-in. diameter plug and a machine canister neck is leak-tight to at least 10^{-8} atm·cc/sec helium for a hydrostatic test pressure of 5,000 psi. If the canister neck is heated to 600°C, but not machined prior to welding, then the weld strength as measured by tensile and hydrostatic tests is reduced by about 20%. However, temperature measurements made on the canister neck during glass filling indicate that the maximum neck temperature does not exceed 300°C, so the canister seal weld is capable of withstanding at least 4,000 psi internal pressure while maintaining a leak tightness of 1×10^{-8} atm·cc/sec helium.

Considerable testing of experimental welding equipment has already been completed. These tests have shown that the range of conditions which produce acceptable welds is much wider than the range of expected welding parameters 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.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.2 FABRICATION AND CLOSURE SPECIFICATION

During the DWPF Integrated Cold Run (Appendix 1.200.2), the range of operating parameters selected for use in the DWPF will be retested, with the actual process equipment. Simulated (dummy) and actual canister welds will be made, He leak tested, and their microstructure characterized. The results of this testing will be reported in the WQR.

The quality of the final closure weld in the DWPF will be assured through specification and inspection of the weld plug before use, control of the welding process parameters (force, current, and time), visual inspection of the final weld, and measurements of the displacement of the plug in the final weld.

Documentation

The Waste Form Qualification Report (WQR) will include the canister procurement specifications. The WQR will also include a report on the parametric testing of weld conditions and associated leak rates, and validation of the parametric testing during the Integrated DWPF Cold Run (see Appendix 1.200.2).

The Production Record (Appendix 1.200.1) for each canistered waste form will certify that the canister components and the entire canister were fabricated according to approved drawings and procedures, and meets the procurement specifications. Records of inspection to verify that canisters were fabricated according to specifications will be included in the Production Records.

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 800.

References

1. B. J. Eberhard, and J. W. Kelker, "High Current Resistance Welding of Nuclear Waste Canisters," **Welding Journal**, (1982).

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

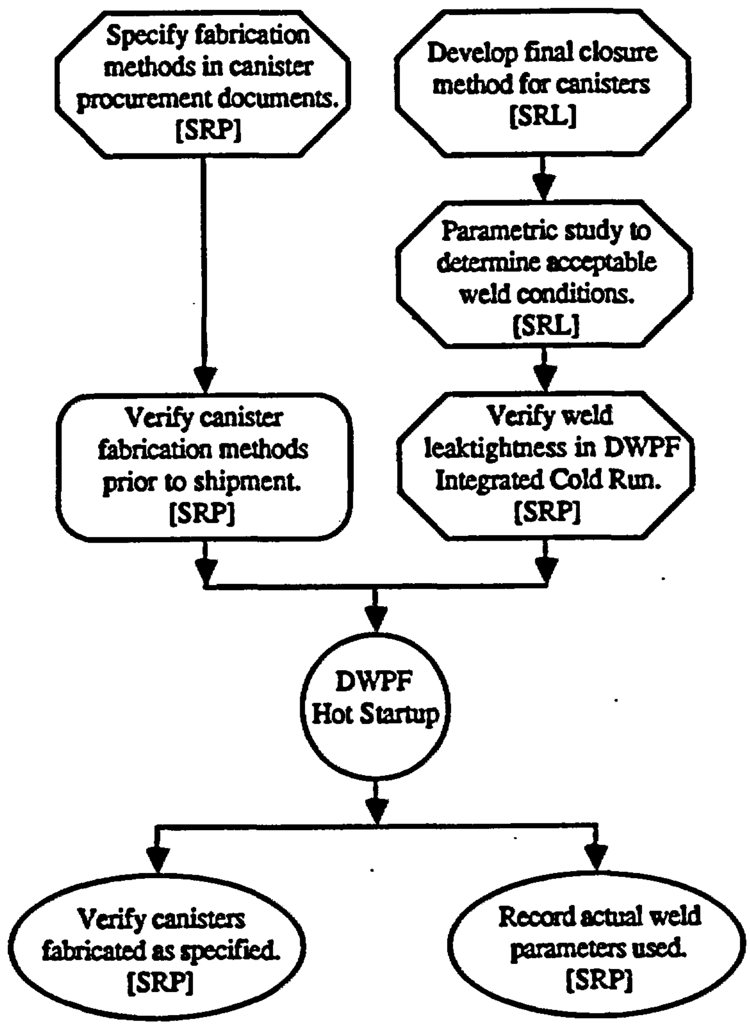
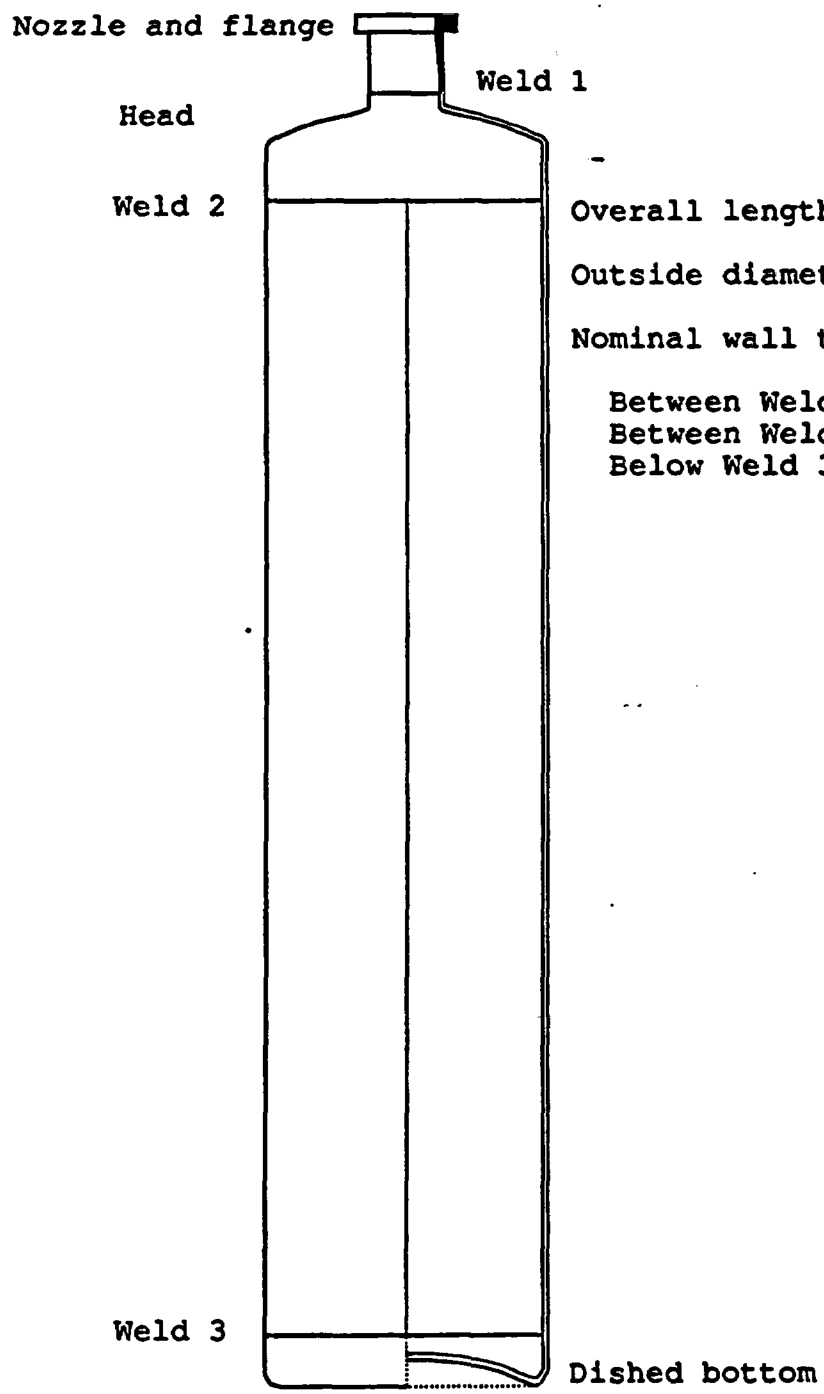


FIGURE 4.200.2 Components and overall dimensions of the DWPF canister.



Overall length 118.00±0.06 in.

Outside diameter 24.00±0.12 in.

Nominal wall thickness:

Between Weld 1 and 2	0.625 in.
Between Weld 2 and 3	0.375 in.
Below Weld 3	0.50 in.

PART TITLE: CANISTER SPECIFICATIONS

ITEM TITLE: 2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

2.3.1 Identification

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

2.3.2 Labeling

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

Rationale

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

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the waste package's permanent written records."

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

Compliance Strategy

The alphanumeric code planned for identifying the canistered waste forms is a six digit alphanumeric code consisting of one letter and five numbers. The label lettering will conform to the specification.

The label itself will be fabricated from an austenitic stainless steel to assure compatibility with the canister. The reference label is bead-welded to the canister surface. 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.

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. Several other initial actions have been performed to satisfy this specification, including

- Performing studies of various labels and labeling methods to choose a reference process.

- Selecting a lettering shape and style.

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- Fabricating test labels, and confirming the visibility of the labeling scheme even after frit blasting.

- Estimating the service life of the label.

These studies have now been completed, and their recommendations included in the canister procurement documents. The reference DWPF canister labeling method is to bead-weld characters on the canister surface. The type face is 144 point (2-inch) sans serif style, Megaron Medium, full-width. Letters are to be spaced 1/4 inch apart. The alphanumeric code for identifying the canistered waste forms is a six digit alphanumeric string consisting of one letter and five numbers. A label is placed on the shoulder and the barrel 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 0.06 inches. 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.

The welding rod used to bead weld the label characters onto the canister surface will be Type 308 austenitic stainless steel. This will be 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. Thus, after filling the canister, the DWPF will not need to take any special precautions to protect the canister label.

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 350). 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.

Documentation

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 canister and canistered waste form. All of the records which support the information reported in the Production Records will be keyed to that code.

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

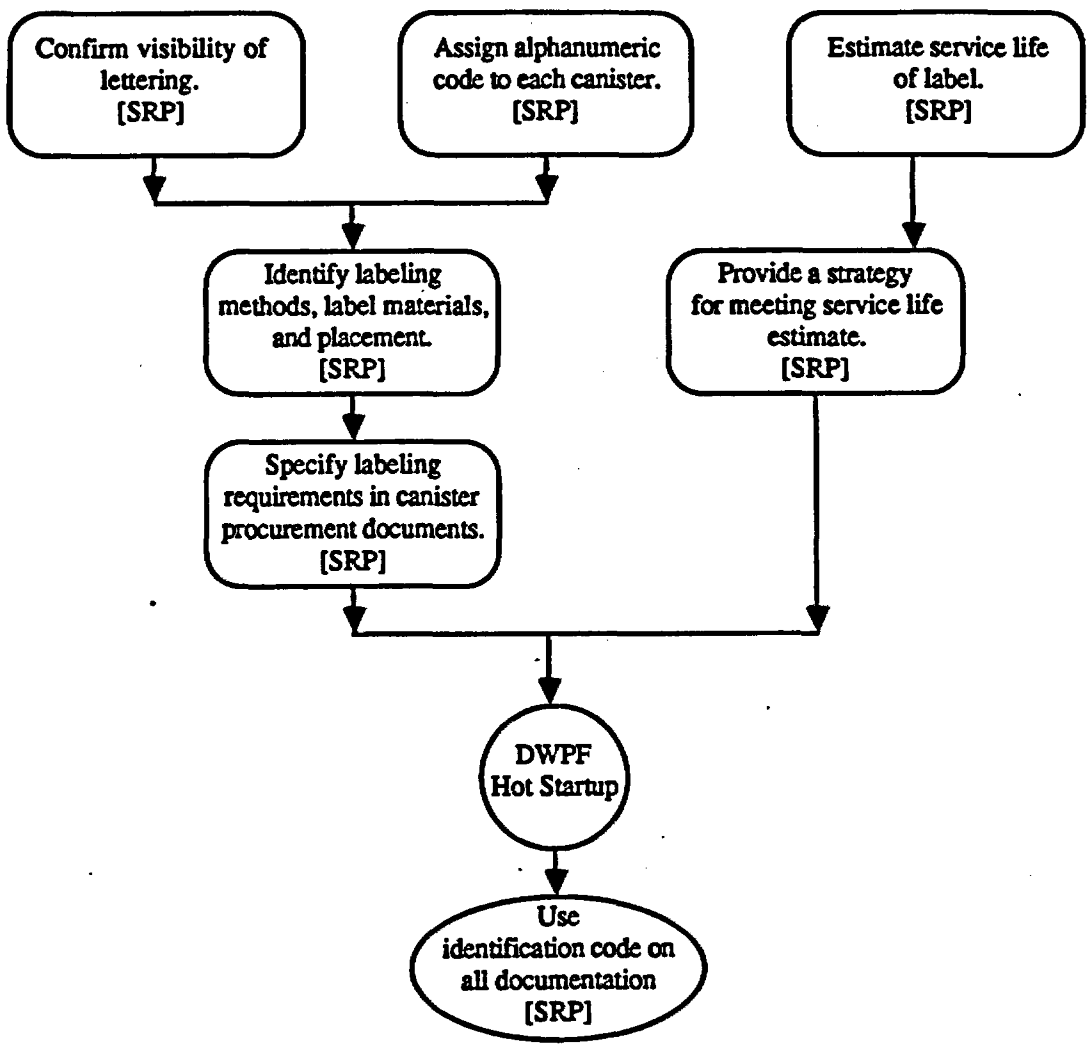
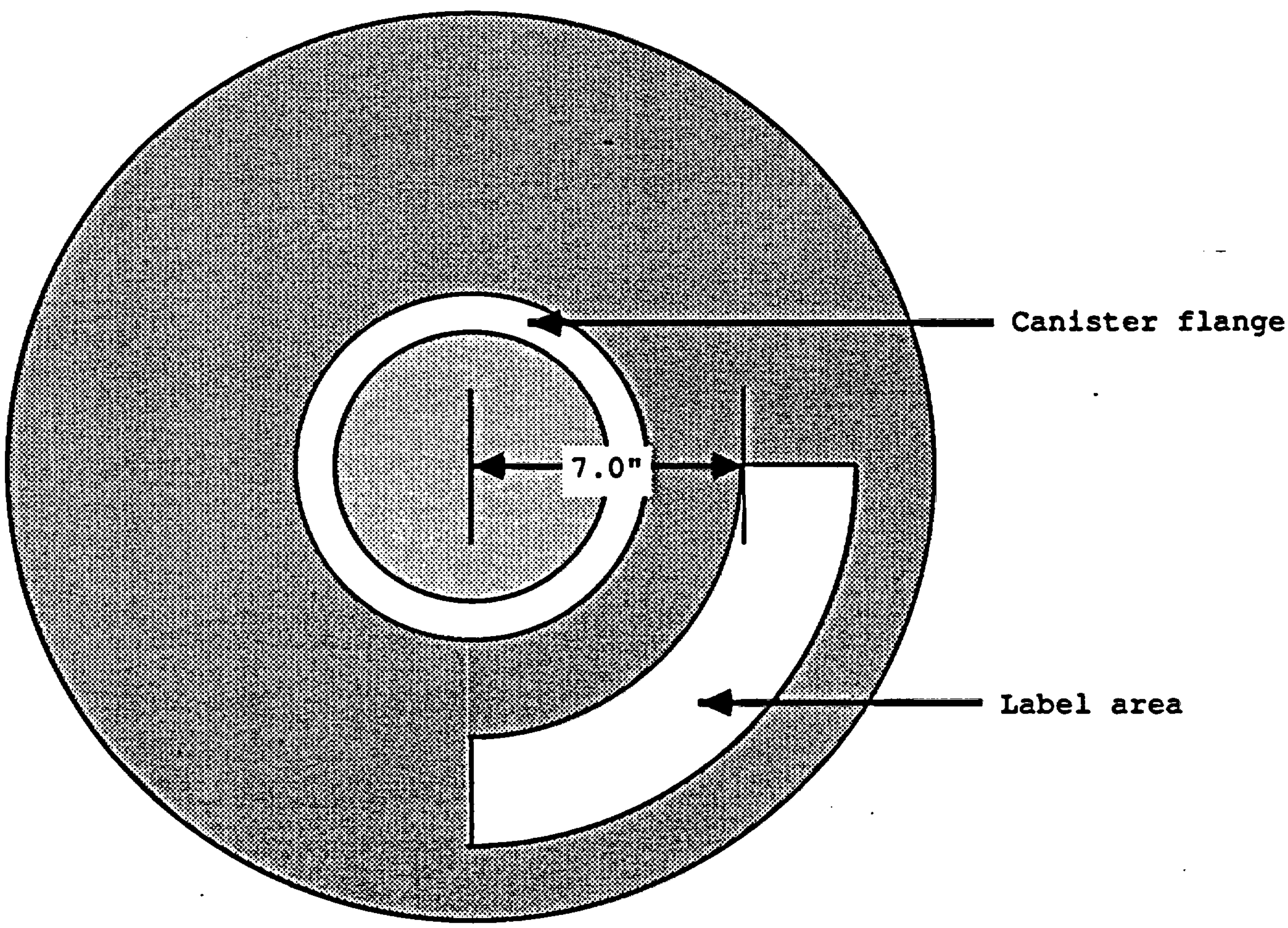
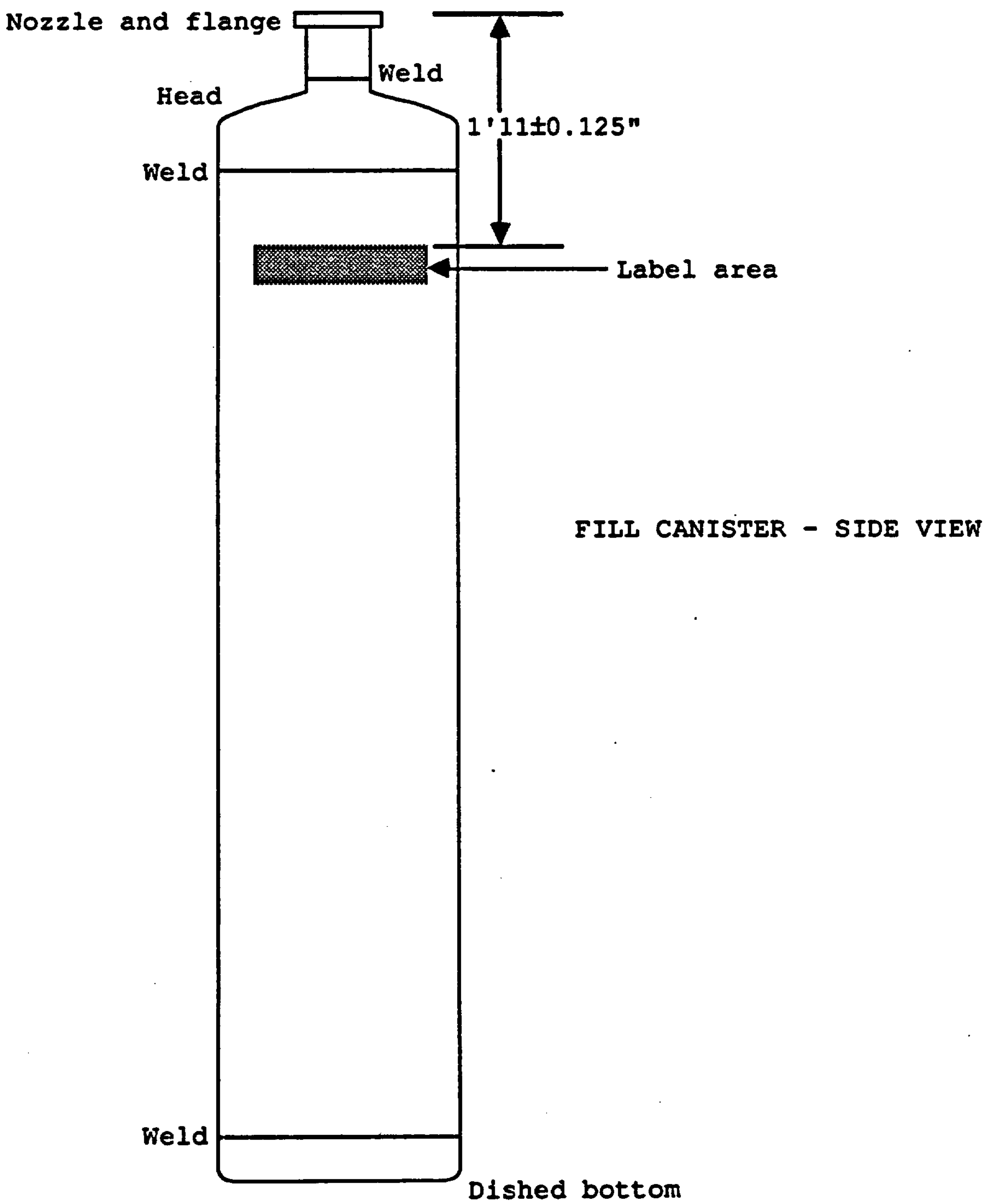


FIGURE 4.300.2 Placement of top label on DWPF canister



FILL CANISTER - TOP VIEW

FIGURE 4.300.3 Placement of side label on DWPF canister



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

3.1 FREE LIQUID SPECIFICATION

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

Rationale

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

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 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 vacuum.

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 canister closure seal will be inserted into the canister neck after filling, and before canister decontamination, to prevent inleakage of the decontamination slurry. Every temporary canister closure will be tested to ensure it is water tight. Administrative controls will be used to prevent

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

the introduction of any free liquids into the canisters before or after glass filling.

It is also possible that liquid could be introduced into the canister by the organic sealing aid (Dow Corning® 200 fluid). This possibility is discussed in detail in Part 5, Item 250.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.100.1. The initial action taken was to develop a water tight 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 is made at the top of the canister nozzle, as soon as possible after canister filling is completed. 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 4, Item 200). As the hot sleeve and the plug equilibrate, the hot sleeve shrinks around the plug to form a water tight seal (see Figure 5.100.3). Both the sleeve and the temporary seal plug are purchased to specifications in the canister procurement document. The flange sleeve is tested for leak tightness as a part of acceptance testing of the fabricated canister.

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

If the temporary seal is not water tight, it will be re-worked be-

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

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fore transfer of the canister is allowed. In the re-work process, the nozzle 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-fitted in the nozzle to replace the original seal. After re-work, the temporary seals are then retested.

After the canister is transferred to the Canister Decontamination Cell and decontaminated, it is transferred to the Weld Test Cell. Here, the sleeve and seal plug are pressed down into the nozzle, using a die press, to make room for final closure weld plug. A circular weld plug is then placed in position, and resistance welded as described in Part 4, Item 200. This final closure prevents liquids from entering the canister during storage of the canisters at Savannah River.

Documentation

The Waste Form Qualification Report will include a report on the absence of liquid in borosilicate waste glass at temperatures up to the glass transformation temperature. 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. A report of the impact of Dow Corning® 200 fluid on the DWPF's ability to meet this specification will also be included in the WQR.

The Production Record for each canistered waste form will include the results of the leak test of the temporary canister closure of the canistered waste form prior to decontamination, including any extraneous materials which are known to be contributed by the organic sealing aid. The Production Record will also certify that appropriate controls were used to prevent the introduction of free liquids into the canistered waste form. This certification will be based upon:

- The ability of the temporary seal emplaced immediately after filling to prevent materials, particularly liquids, from entering the canister. The Production Records will contain the results of leak testing the temporary seal.

- The ability of the canister closure weld and fabrication welds

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.1 FREE LIQUID SPECIFICATION

to prevent these materials from entering the canister. The certification of the canister fabrication and closure welds described in Part 4, Item 200, will be used to satisfy this requirement.

- Any active control procedures taken to prevent these materials from entering the canister. The Production Records will cite these by their unique identification number, including the version actually used. Any such procedures will be lifetime quality records.

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).

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

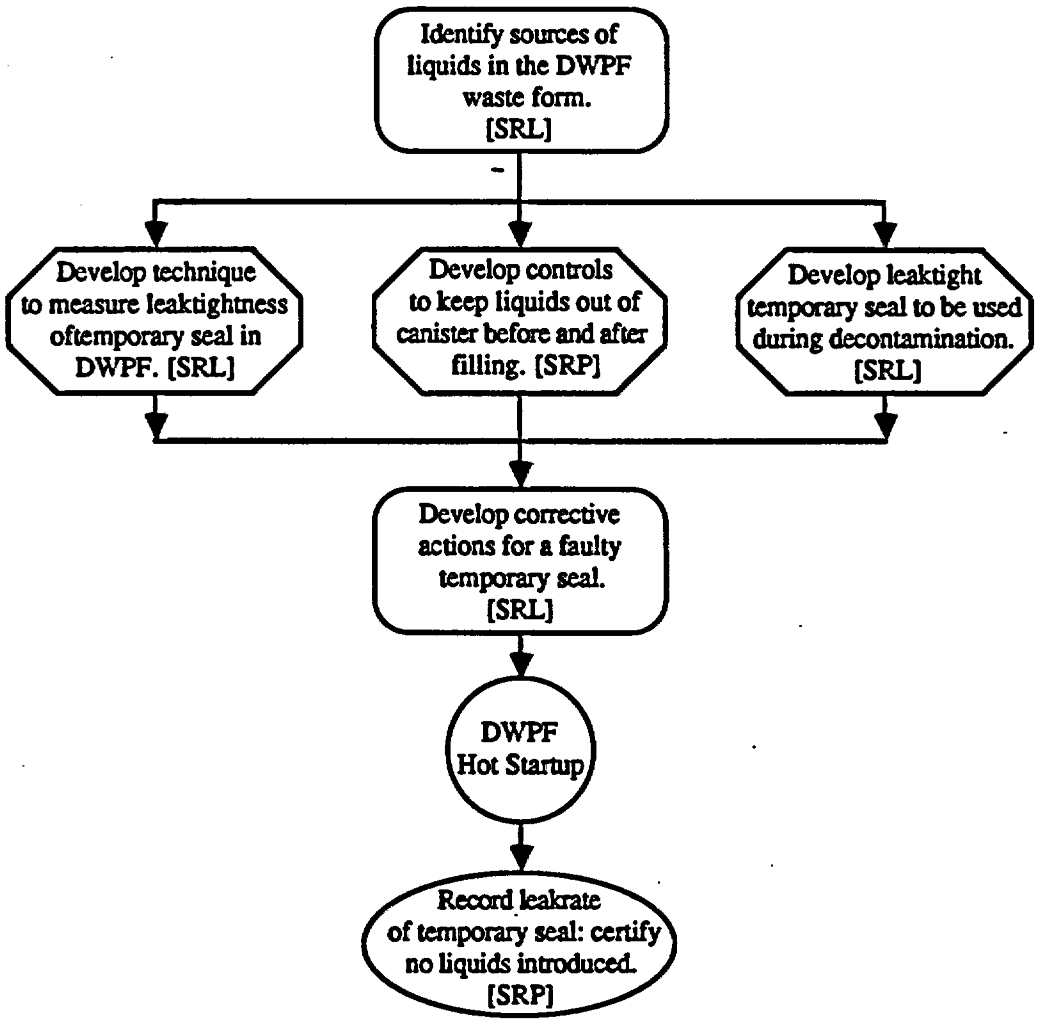


FIGURE 5.100.2 Temporary shrink-fit seal process.

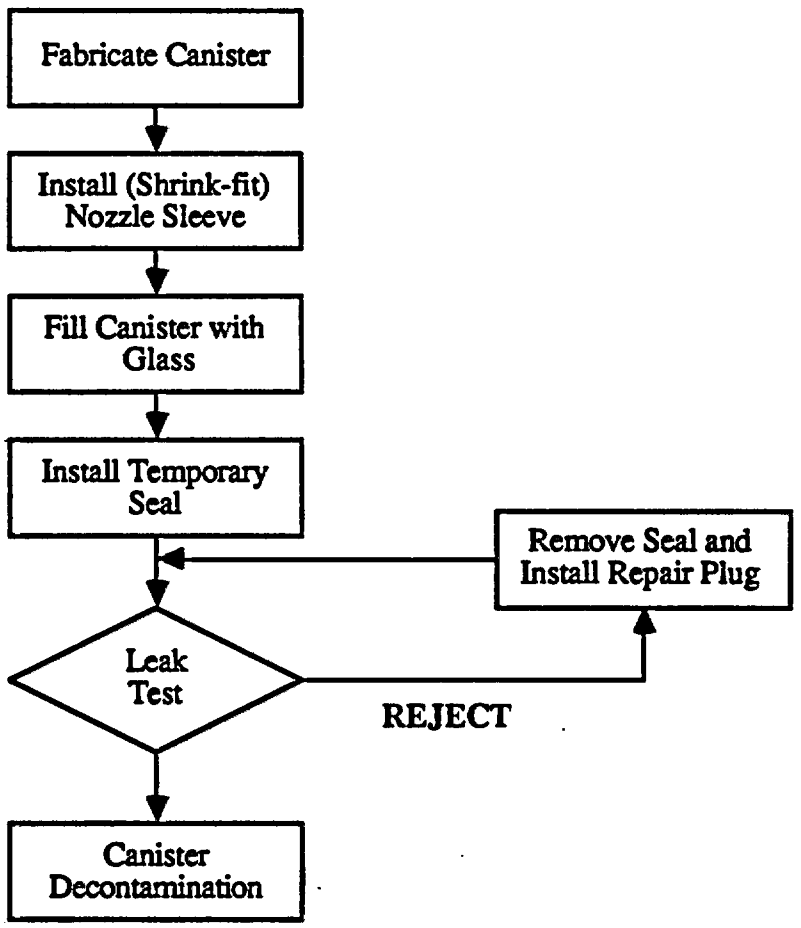
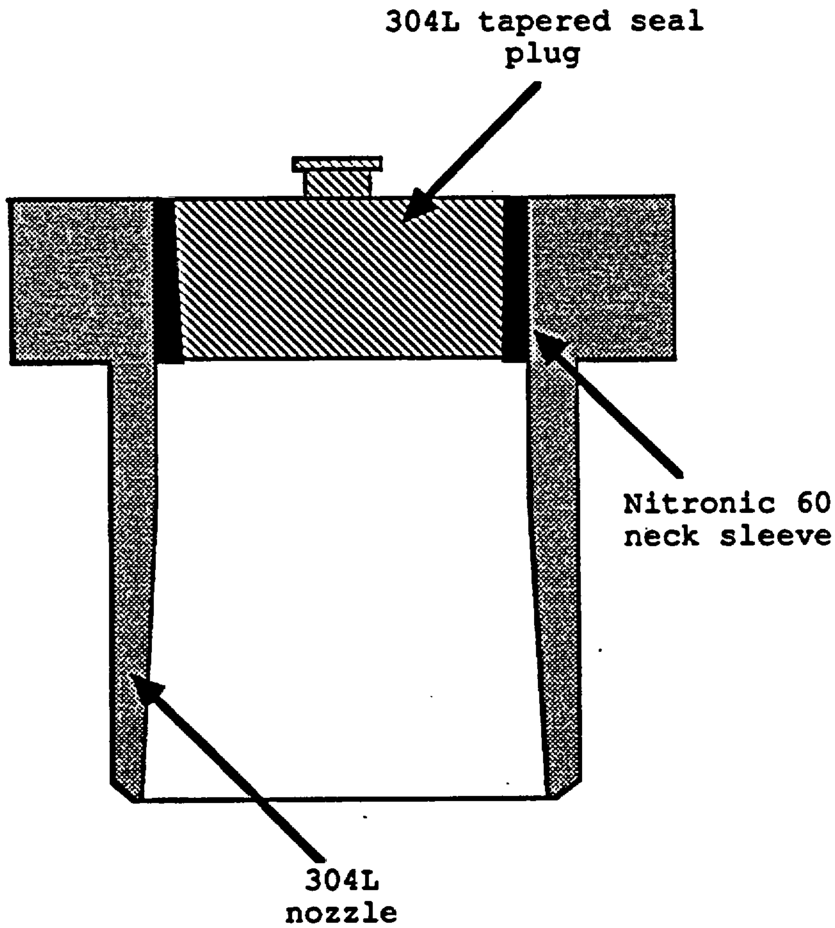


FIGURE 5.100.3 Completed temporary shrink-fit seal



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

3.2 GAS SPECIFICATION

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

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

Rationale

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

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

The value for the maximum initial gas pressure, 7 psig, was chosen because it has the following attributes: it is

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ITEM TITLE: 3.2 GAS SPECIFICATION

low enough to preclude significant stresses in the canister wall arising from internal pressurization, both initially and after the anticipated helium production from alpha decay over the containment period; plus, it is to avoid introducing unnecessary restrictions that will not materially contribute to the overall function of the canistered waste form in the repository.

In general, an internal pressure P in a cylindrical vessel of diameter D and wall thickness t produces a tensile hoop stress of

$$\sigma_H = PD/2t$$

and a tensile longitudinal stress of

$$\sigma_L = PD/4t$$

in the wall of the vessel (Popov, 1959). For a vessel made from Type 304L stainless steel, the yield strength at 500°C would be at least 14,000 psi (ASM, 1980). The more rapid cooling of the canister wall than the bulk of the glass after pouring as well as differences in the coefficients of thermal expansion of the two materials are expected to lead to tensile thermal stresses approaching or exceeding the yield strength of the stainless steel (Baxter, 1983). In order for the stresses due to internal pressurization to be insignificant in comparison, it would be sufficient to limit them to a small percentage of the yield strength. If the hoop stress is limited to 10 percent of the yield strength at 500°C or 1400 psi, the maximum internal pressure would be 44 Psi at 500°C, which is equivalent to 17 psi at 25°C.

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

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

Compliance Strategy

The DWPF will exclude free gases, other than cover 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. The initial task, now completed, was identification of the sources of gas in the canistered waste form.

The canister is filled with glass, and the temporary canister closure 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, the helium used in leak testing, and possibly gases generated by the organic sealing aid (see Part 5, Item 250).

It may be 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, indicate a maximum of 4.6 grams of water vapor will be trapped in DWPF canistered waste form atmosphere. The somewhat elevated steady-state temperatures expected during interim storage at the DWPF will prevent this water vapor from condensing.

- Demonstration that the canistered waste form does not contain free gas (other than those allowed) at time of production, and will not generate any at temperatures up to the transformation temperature, T_g.

The gases that might be generated at temperatures up to the transition temperature will be determined from either the technical literature or new experimental evidence, as necessary. All available evidence indicates that the canistered waste form does not

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

contain free gas. However, DWPF glass may release small amounts of volatile materials upon exposure to T_g, which will recondense when the canistered waste form cools. The composition and amounts of such materials will be reported in response to Specification 3.9 (Part 5, Item 600).

- Determine gas composition as a result of radioactive decay.

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 limit. The organic sealing aid, if used, will also be investigated to determine if it releases gases when irradiated.

- Development of controls to exclude free gases from the canistered waste form.

Administrative controls will be used to prevent nonconforming 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.

Documentation

The Waste Form Qualification Report will include a report on the absence of free gas in borosilicate waste glass, gas generation due to exposure to the transition temperature, and gas generation due to radioactive decay. The WQR will also include a report on the controls to be used to prevent introduction of other gases into the canistered waste form.

The Production Record for each canistered waste form will certify that appropriate controls were used to exclude free gases (other than those present in the Vitrification Building's atmosphere) from the canistered waste form. This certification will be based upon:

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.2 GAS SPECIFICATION

- The ability of the temporary seal emplaced immediately after filling to prevent materials from entering the canister. The Production Records will contain the results of leak testing the temporary seal.

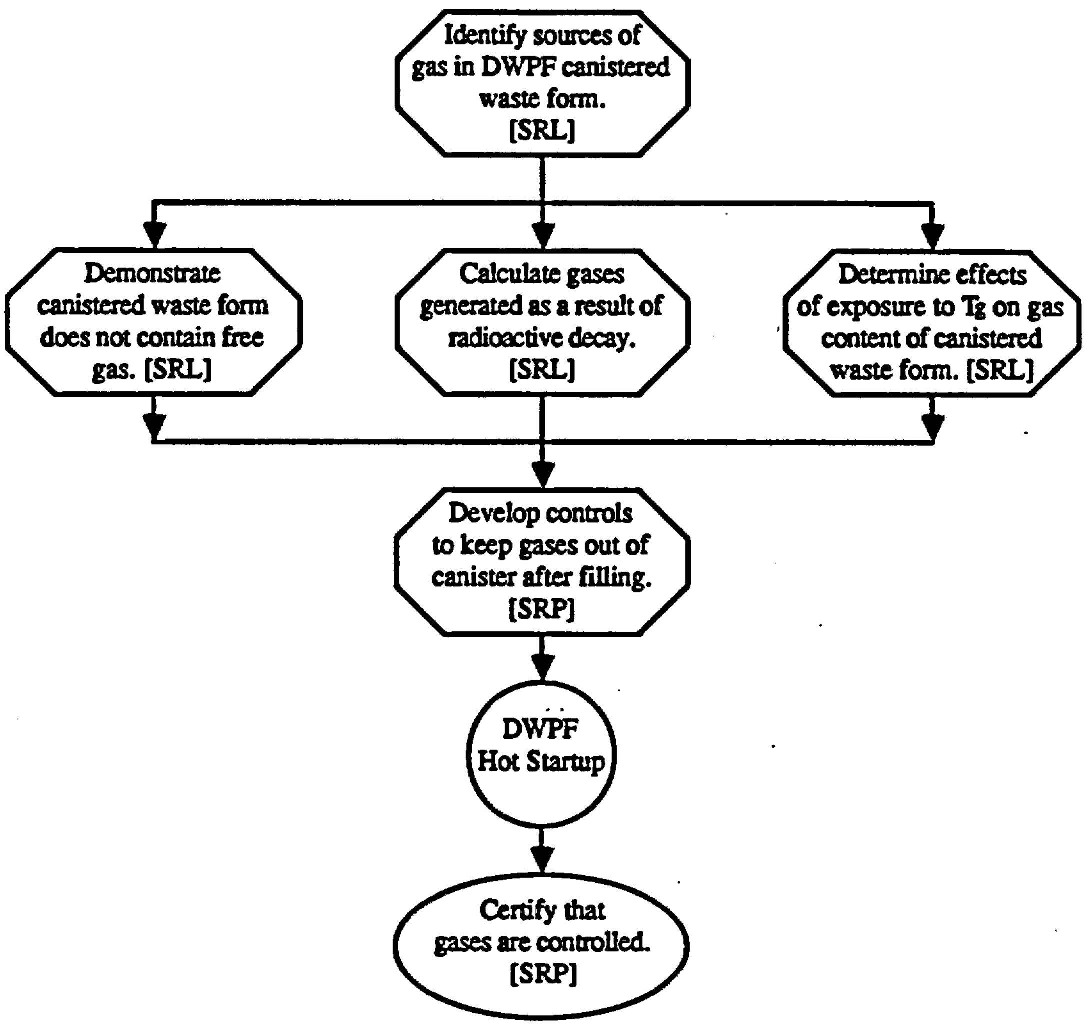
- The ability of the canister closure weld and fabrication welds to prevent gases from entering the canister. The certification of the canister fabrication and closure welds described in Part 4, Item 200 will be used to satisfy this requirement.

- Any active control procedures taken to prevent these materials from entering the canister. The Production Records will cite these by their unique identification number, including the version actually used. As this implies, any such procedures will be lifetime quality records.

Reference

1. 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 (1983).

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

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

Rationale

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

The regulatory requirements as outlined in 10 CFR 60.135 (b)(1) state that, "The waste package shall not contain explosive or pyrophoric materials in an amount that could compromise the ability of the underground facility to contribute to waste isolation or the ability of the geologic repository to satisfy the performance objectives."

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

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, processing steps, and physical barriers to prevent the ingress of extraneous (non-waste glass) materials.

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

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.200.1. The DWPF will first demonstrate that borosilicate waste glass does not contain explosives, pyrophorics, or combustibles. 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. Because the waste glass in a filled canister has already been subjected to temperatures much greater than the transition temperature, any further exposure of the glass to the tranistion temperature does not cause observable changes. In tests performed at SRL, and at the University of Florida, exposure of simulated waste glasses similar in composition to the DWPF glass to temperatures somewhat greater than the transition temperature 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]

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 gasketed 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 extraneous 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). The final canister closure weld will then prevent prohibited materials from entering the canister (see Part 4, Item 200).

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

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

Documentation

The Waste Form Qualification Report will include a report on the absence of explosives, pyrophorics, and combustibles in borosilicate waste glass. The WQR will also include a report on the controls used to keep explosives, pyrophorics, and combustibles out of the canistered waste form.

The Production Record for each canistered waste form will state that appropriate controls were used to prevent the introduction of explosives, pyrophorics, or combustibles into the canistered waste form. This certification will be based upon:

- The ability of the temporary seal emplaced immediately after filling to prevent prohibited materials from entering the canister. The Production Records will contain the results of leak testing the temporary seal.

- The ability of the canister closure weld and fabrication welds to prevent prohibited materials from entering the canister. The description of the canister fabrication and closure welds (described in Part 4, Item 200) will be used to satisfy this requirement.

- All active control procedures taken to prevent the prohibited materials from entering the canister. The Production Records will cite these control procedures by their unique identification number, including the version actually used. As this implies, all such procedures will be lifetime quality records.

References

1. 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).

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).

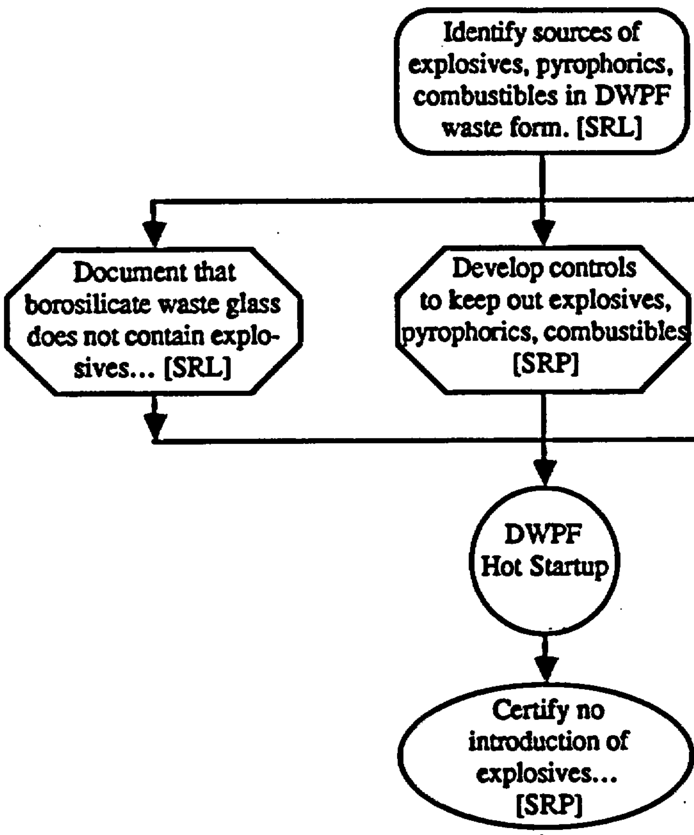
PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

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

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).

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

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

Rationale

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

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

Compliance Strategy

It is important to prevent the introduction of organic materials to the canister that could potentially mobilize the radionuclides by the formation of complexes or 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 SRP. The vitrification process, operating at about 1150°C, will volatilize any organics that are present in the waste feed stream. 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 DWPF waste glass will be vitrified at 1150°C. Organics present in the waste feed streams are not incorporated in the glass, and become part of the melter off-gas. Organics present in the canister prior to filling will volatize when the molten glass

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.4 ORGANIC MATERIALS SPECIFICATION

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.

The tasks planned to satisfy this specification are outlined in Figure 5.250.1. The initial task, now completed, was to identify possible sources of organic materials. There are three types of organic materials which could enter the canistered waste form after filling: greases from canister fabrication, an organic fluid which has been used to assist in making the temporary canister closure, and hydraulic fluid from the welding press. Subsequent tasks are to find means to minimize or eliminate these organic materials.

- Degreasing agents.

The canisters themselves are degreased by the manufacturer prior to receipt at SRP. This is currently specified in the canister procurement documents. In the unlikely event that some grease escaped notice, it would volatilize when the canister was filled with molten glass.

- Organic fluid used in making temporary canister closure.

Dow Corning® 200 fluid has been used to assist in making a leak-tight temporary seal. During operability testing, it will be determined if the Dow Corning® 200 fluid is necessary. If it is necessary, the amount used will be minimized and controlled. The Dow Corning® 200 fluid is not corrosive, and can withstand 500°F temperatures. Exposure to radiation causes it to break down to CO_2, SiO_2, and H_2O. Thus, even if it is contained in the canistered waste form, it is unlikely to produce complexing agents, or otherwise enhance radionuclide release.

- 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 canis-

ter surface. The effectiveness of the drip pan design will be reviewed. If necessary, the design will be improved.

In subsequent tasks, simulated DWPF canisters will be prepared, and analyzed for the presence of organics. This will most likely be accomplished by extraction processes in which any organics present would be dissolved and the resultant solutions analyzed.

Documentation

The Waste Form Qualification Report 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 will also be reported. If it is determined that the Dow Corning® 200 fluid is necessary for a leaktight temporary seal, then measures taken to limit the amount used will be reported.

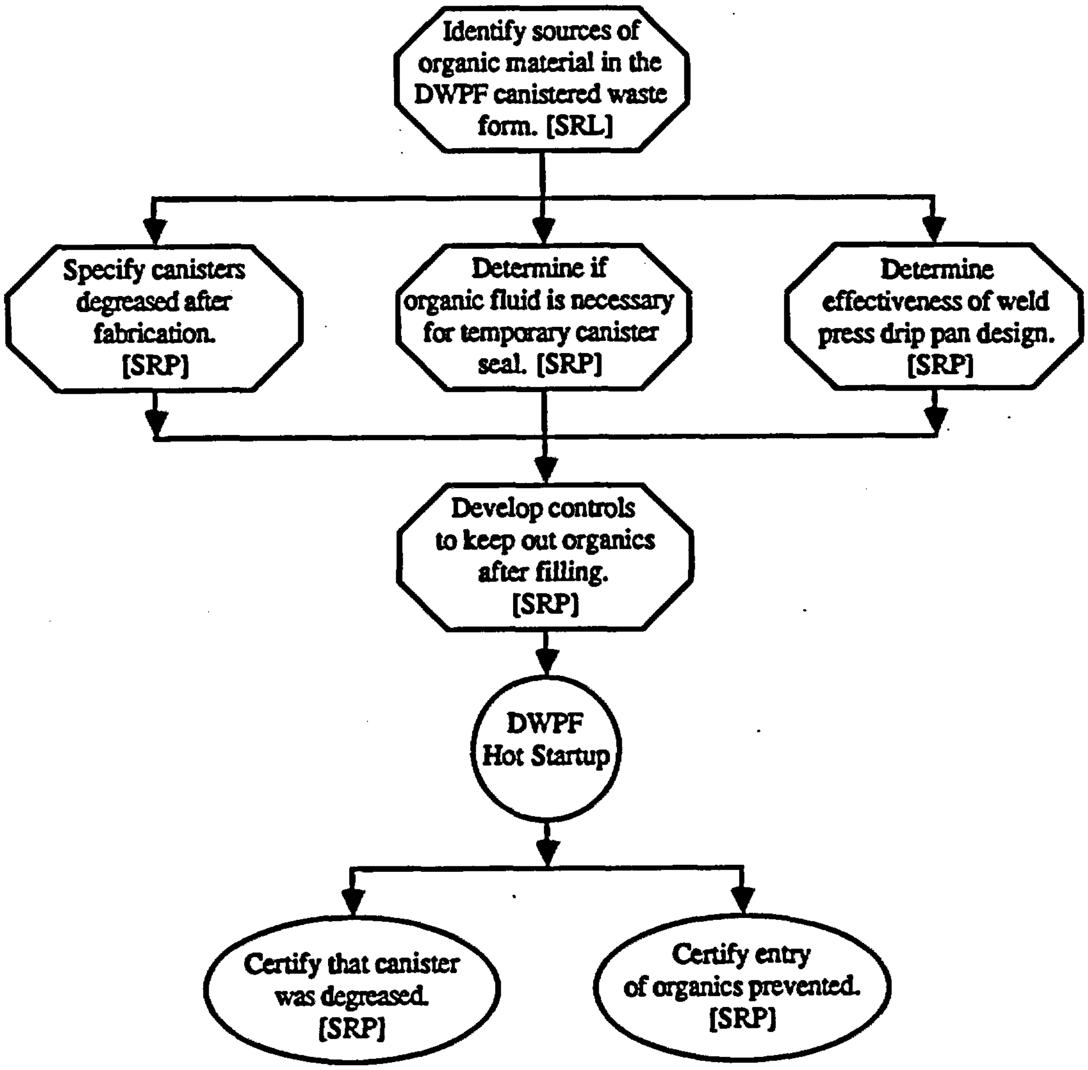
The Production Record for each canistered waste form will certify that appropriate controls were used to prevent the introduction of organics into the canistered waste form. This certification will be based upon:

- The ability of the temporary seal emplaced immediately after filling to prevent organic materials, particularly liquids, from entering the canister. The Production Records will contain the results of leak testing the temporary seal.

- The ability of the canister closure weld and fabrication welds to prevent organic materials from entering the canister. The certification of the canister fabrication and closure welds described above will be used to satisfy this requirement.

- Any active control procedures taken to prevent these materials from entering the canister. The Production Records will cite these by their unique identification number, including the version actually used. As this implies, any such procedures will be lifetime quality records.

FIGURE 5.250 Tasks planned to satisfy Specification 3.4, Organic Materials Specification



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 FREE VOLUME SPECIFICATION

3.5 FREE VOLUME SPECIFICATION

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

Rationale

In general, free-volume is to be minimized for the following reasons: 1) repository design; 2) economical use of repository space; and 3) less volume of water in contact with waste form in the event of breach of containment followed by infiltration of ground water.

Compliance Strategy

The DWPF canistered waste forms will be filled as full as is practicable in order to minimize the number of canistered waste forms produced. At the beginning of radioactive operations, the nominal free volume at the completion of filling will be ≤ 15 percent. The free volume is expected to decrease as experience is gained in operation of the DWPF equipment.

The glass level will be monitored by gamma emission and neutron transmission and will be compared with the glass level as calculated from the weight of the glass to assure control of the fill level. The glass level will also be visually tracked by observing the change in color of the canister external surface. It is anticipated that less than 2% of the DWPF canistered waste forms will have free volumes in excess of 20 percent. These canisters could be produced as a result of a process upset, draining the melter at the end of its life, equipment failures, or operator error.

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ITEM TITLE: 3.5 FREE VOLUME SPECIFICATION

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.300.1. Three independent methods will be used to monitor the glass level during the canister filling operation in the DWPF melt cell. These include neutron transmission, intrinsic gamma emissions, and the measurement of canister weight. Visual examination of the oxidation of the canister's external surface will provide another independent means of determining the glass level in the canister.

The neutron transmission method senses the glass level directly, can detect intermediate thicknesses of glass indicative of uneven canister filling, and is independent of waste loading or level of radioactivity. The system is designed to detect the arrival of the glass level at the 40, 60 and 91 inch canister elevations. Each elevation is equipped with BF_3 counting systems designed to signal the approach, and arrival, of the glass level. Alarms sound if the counting rate is reduced by 15% or more.

The reference design canister is filled with approximately 165 gal of glass (22.1 ft^3, or 626 L) to a fill height of 91 in (231 cm). This corresponds to a nominal weight of 3650 lb. (1650 kg, based on an average measured cast glass density of 165 lbs/ft^3) for the design-basis glass, and is about 85% of the available canister volume. The void volume of 15 % was chosen to allow sufficient room in the canister so that possible upset conditions could be tolerated during processing (as detailed below).

The DWPF canister has a total internal volume of 26.0 ft^3. After operating experience is gained, it may be possible to fill the canister to the top of the straight section of pipe at the intersection of the head with the cylinder. This volume is 25.3 ft^3 (715L) corresponding to a glass weight of 4175 lbs (1900 kg) and a fill height of 104 in (264 cm).

A 15% void space has been made available for: "roping" of the glass stream causing voids in the frozen melt; and the possibility of overfilling the canister due to malfunction of load cells, level instrumentation, failure of pouring equipment or operator error. The first two of these could also cause the canistered waste

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.5 FREE VOLUME SPECIFICATION

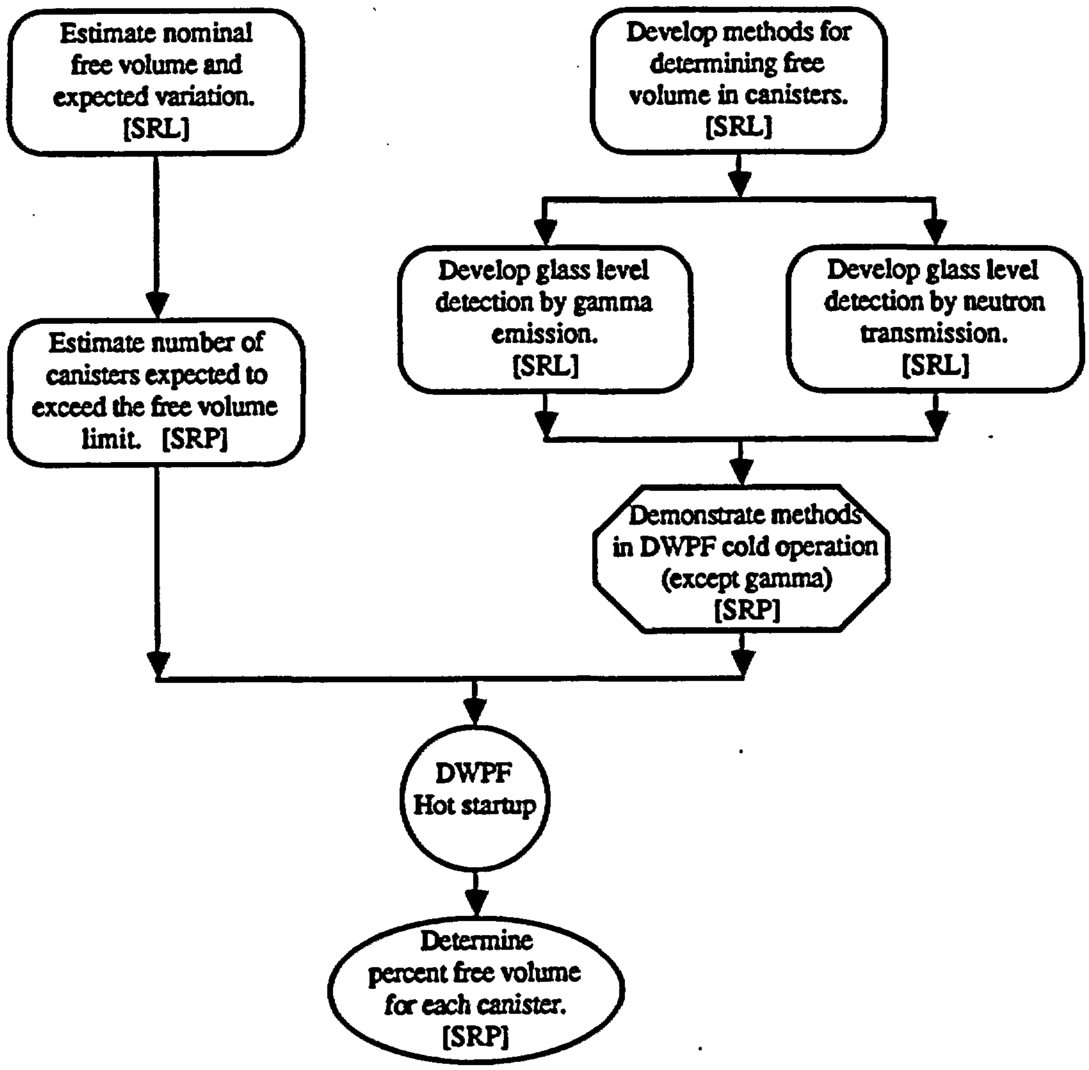
form to exceed the specified 20% free volume. In addition, at the end of each DWPF melter's life, the melter will be drained. Based on the current melter design, the last canister would be half full. This canister may be completely filled when a new melter is put into service, or may be sealed as is for eventual shipment to the repository. Although there is a nominal limit on the free volume of 20% of the total internal volume, the Waste Acceptance Preliminary Specifications recognize that this may be exceeded occasionally. The Production Records for each canister which has greater than 20% free volume will clearly indicate this, but no other action will be taken if this value is exceeded. While it is not possible to definitively estimate the frequency of such occurrences without long-term operating experience, it is anticipated that no more than 2% of the canistered waste forms produced in the DWPF will exceed the free volume limit of 20%.

Documentation

The Waste Form Qualification Report will include a report on the nominal free volumes, the expected variations, and the number of exceptions expected. The WQR will also include a report on the methods to be used in determining the free volume of a canistered waste form and the results of testing of those methods.

The Production Record for each canistered waste form will include the percent free volume in that canistered waste form. This information will be obtained from both the neutron and gamma level detectors.

FIGURE 5.300.1 Tasks planned to satisfy Specification 3.5, Free Volume Specification



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.6 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

3.6 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

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

Alpha radiation: 220 dpm/100 cm^2
Beta and Gamma radiation: 2200 dpm/100 cm^2.

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

Rationale

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

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

Compliance Strategy

The canistered waste form will be decontaminated by slurry frit blasting.[1-3] The canistered waste forms will be visually inspected for waste glass on the external surfaces of the canister. Assurance that the canistered waste forms do not exceed the specified contamination levels will be provided by a smear test of the canister's external surfaces in the DWPF before transfer to the Interim Glass Storage Building.

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ITEM TITLE: 3.6 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.350.1. The initial actions, now completed, were to develop a decontamination method for the canistered waste form, and to develop a technique to remove visible waste glass from the canister exterior.

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 generates no wastes which cannot be recycled to the vitrification process. In this process, the canister is placed in the DWPF Canister Decontamination Chamber (see Figure 5.350.2). 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 dried by air. 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.

Based on process development work at SRL, a single slurry frit blasting cycle will remove 70 g of canister material (metal and contaminated oxides), or approximately 10 mg/in^2 of canister surface area. It has been shown that a conservative estimate of the minimum metal removal required to achieve the specified level of decontamination is 7 mg/in^2.

After frit blasting, the canister will be checked for residual contamination, using a smear test. This test involves wiping a standard 1" diameter smear paper against the surface of a rotating canister. The smear paper mount will be handled remotely, and several smears will be made to ensure that the results are representative. The smear will cover an area of ~100 cm^2. If the contamination is within the specified limits, the canister will be transferred to the Weld Test Cell for final closure. If the contamination level is too high, the canister will be decontaminated again by slurry-blasting until the contamination level is within

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the specified limits. A confirmatory smear test is made in the Weld Test Cell prior to transfer to the Interim Storage Facility. All smearing will be performed according to procedures.

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 before the canister is transfered 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. A remote method of supporting the needle gun and of collecting the glass particles generated during operation will be developed.

Documentation

The Waste Form Qualification Report (WQR) will include a report on the smear technique to be used to show compliance. The WQR will also include a report on the decontamination method, the amount of material removed during decontamination, and the technique for removing visible waste glass from the canister exterior.

The WAPS require that the DWPF report, in the Production Records, the smear test results for each canister. If the level of contamination exceeds 220 alpha dpm/100 cm^2, or 2200 beta or gamma dpm/100 cm^2, the canister will be decontaminated again, before it leaves the vitrification building. In this case, the results of a confirmatory smear test will also be reported.

The DWPF will also inspect the canister to ensure that there is no visible glass adhering to the outer surface. The inspector will be identified by name and badge number. If there is visible glass on the outside of the canister, the procedures used to remove this glass will be identified, as well as the individuals performing them.

References

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

HQW.880229.0013

Office of Civilian Radioactive Waste Management

Office of Geologic Repositories

Quality Assurance Requirements for High-Level Waste Form Production

(OGR/B-14)

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February 1988

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

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PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.6 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

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 (September, 1984).

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 (September, 1986).

FIGURE 5.350.1 Tasks planned to satisfy Specification 3.6, Specification for Removable Radioactive Contamination on External Surfaces

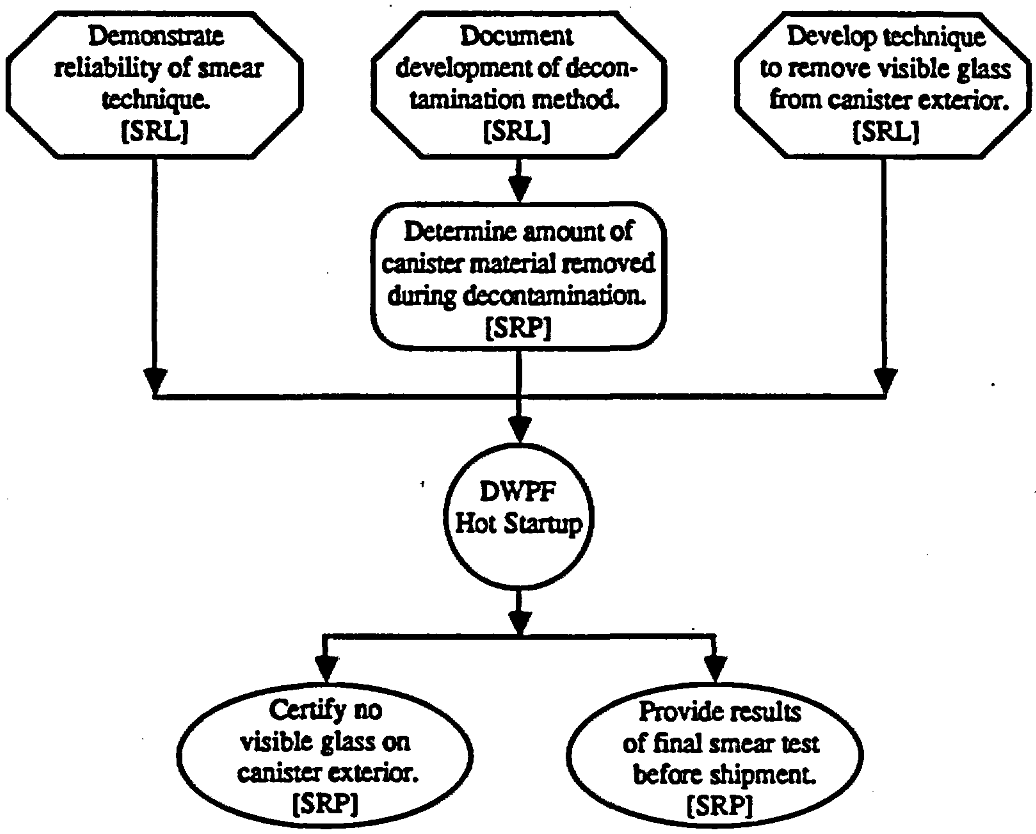
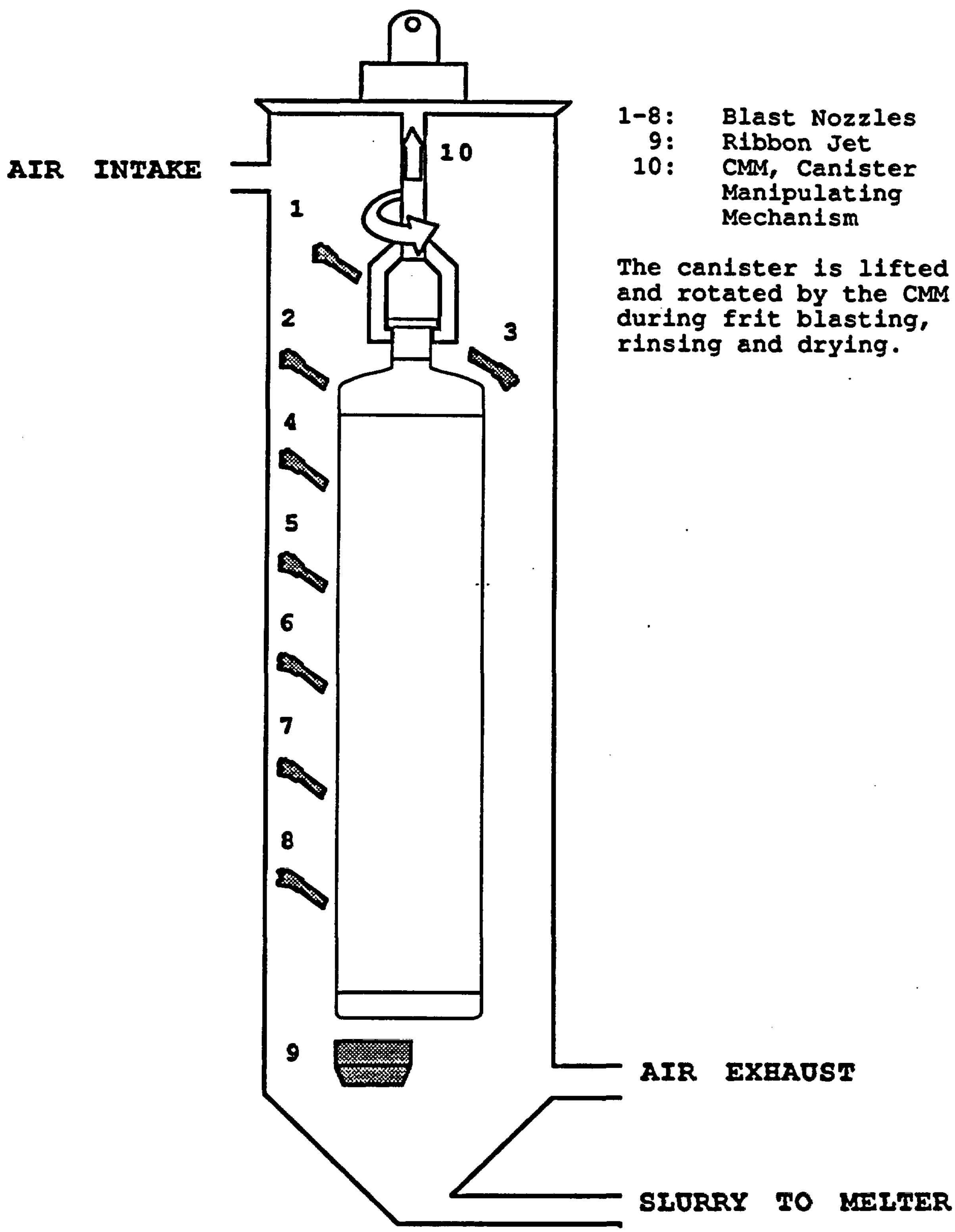


FIGURE 5.350.2 DWPF Canister Decontamination Chamber



1-8: Blast Nozzles
9: Ribbon Jet
10: CMM, Canister Manipulating Mechanism

The canister is lifted and rotated by the CMM during frit blasting, rinsing and drying.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7.1 HEAT GENERATION PROJECTIONS

3.7 HEAT GENERATION SPECIFICATION

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

3.7.1 Heat Generation Projections

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

Rationale

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

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

An accuracy of ± 15 percent is judged to be a reasonable working value, acceptable to both the repository project and to the producer. Information on the range of expected variation in heat generation rates is necessary to allow assessment of uncertainties in repository performance.

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.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7.1 HEAT GENERATION PROJECTIONS

Implementation

As shown in Figure 5.400.1, this specification will be satisfied by converting the radionuclide inventory projections described in Part 3, Item 300, into projections of heat generation. This will be done by multiplying the amount of each radionuclide by its specific thermal output.

Preliminary estimates of the heat generation rate of DWPF canistered waste forms have already been made. These are primarily based on an early waste blending schedule, which is currently under review. This blending schedule uses sludge that is at least 20 years old at the time of processing, and combines it with soluble salt waste which is aged about 15 years. The first canisters produced from the DWPF in 4QCY90 using 20 year old sludge and 15 year old supernate would generate approximately 460 watts. This feed concentration would then be maintained during the first 4 batches, or ~10 years. Under this schedule, the canister power would vary approximately as shown in Table 5.400.1. For example, at the end of 5 years of production in 4QCY95, the Interim Glass Waste Building would contain 410 canisters averaging 457 watts, 410 averaging 446 watts, 410 averaging 436 watts, 410 averaging 426 watts and 410 averaging 416 watts.

The logistics beyond the first 10 years are still being developed. A very approximate estimate, however, can be made by taking the remaining waste in tanks and decaying that inventory, and then assuming the newly generated soluble salt concentrate waste would be mixed with the older salt waste. The newly generated waste was assumed to be sludge (cooled for 5 years) and supernate (cooled for 15 years), which would generate canistered waste forms producing about 690 watts. Based upon 75% attainment, the backlog of waste would be processed in about 12 years, or by 4QCY2002. Thus, beginning in 2QCY2000, canisters generating 690 watts will be filled. Since the last of the 460 watt canisters would be filled 2QCY2000, then the heat generation rate of canistered waste forms produced in the period between 2QCY2000 and 1QCY2003 is estimated to be:

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7.1 HEAT GENERATION PROJECTIONS

Date	Watts
2QCY2000	460
2QCY2001	530
2QCY2002	605
2QCY2003	690

Documentation

The Waste Form Qualification Report will include a report on the expected thermal output and the range of expected variations for the canistered waste forms.

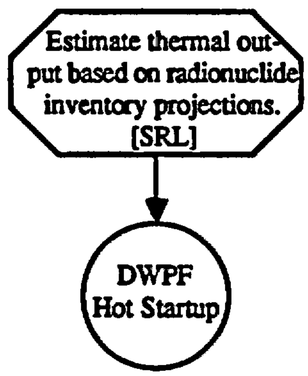
TABLE 5.400.1 Decay Heat of DWPF Canistered Waste Forms

Watts*	462	452	441	431	421	412	402	393	384	376	Canisters
2QCY90	Startup										0
2QCY91	n**										410
2QCY92	n	n									820
2QCY93	n	n	n								1230
2QCY94	n	n	n	n							1640
2QCY95	n	n	n	n	n						2050
2QCY96	n	n	n	n	n	n					2460
2QCY97	n	n	n	n	n	n	n				2870
2QCY98	n	n	n	n	n	n	n	n			3280
2QCY99	n	n	n	n	n	n	n	n	n		3690
2QCY00	n	n	n	n	n	n	n	n	n	n	4100

*Power of first canister produced in the 10 year period is 462 watts. Over the period shown, each canister decays by 8.6 watts/year.

**n = Annual number of canister produced = 410.

FIGURE 5.400.1 Task planned to satisfy Specification 3.7.1, Heat Generation Projections



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7.2 HEAT GENERATION DURING PRODUCTION

3.7 HEAT GENERATION SPECIFICATION

3.7.2 Heat Generation During Production

The producer shall specify in the production records the heat generation rate and its accuracy to ± 15 percent for canistered waste forms at time of shipment. The expected accuracy of the heat generation rates shall be supplied in the WCP. The waste producer shall describe the plan 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 of short-lived radionuclides measured for process safety reasons. If a canistered waste form is produced with a heat generation rate greater than 800 watts, the canistered waste form will be identified as a nonconforming item, and dispositioned as outlined in Part 6, Item 800.

Implementation

The tasks planned to satisfy this specification are outlined in Figure 5.450.1. The heat generation rate will be calculated from the radionuclide inventory of the glass, using standard values 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). The latter will be of importance only in the first five years after production, and only after the DWPF has vitrified current waste inventory, and is producing glass at the same rate that the Savannah River Plant is producing waste.

An example of the results of such a calculation for the design basis glass is shown in Figure 5.450.2. At time of production, the heat generation rate of the glass is calculated to be 693 watts/canistered waste form. The major source of error in the calcula-

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.7.2 HEAT GENERATION DURING PRODUCTION

tion is the radionuclide inventory. As shown in Part 3, Item 400, present estimates indicate that the precision and accuracy of the radionuclide inventory will exceed that required. Currently there are no known sources of bias, so any uncertainties in the reported values are expected to be those due to variations in the radionuclide inventory.

Since the analysis and heat load will be made at the time of manufacture, which could be appreciably before the date of shipment, an estimate of the shipping heat load will be made based on the decay of the production based radionuclides at time of shipment.

If the heat generation rate exceeds 800 watts at time of shipment of the canister from the DWPF, the canister will be identified as a nonconforming item, and then dispositioned according to the procedure outlined in Part 6, Item 800.

Documentation

The Waste Form Qualification Report will include a description of the heat generation rate calculation, and results of tests to determine the extent of any biases in the reported values.

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

The WAPS also require that the DWPF state, in the Production Records, that the reported heat generation rate for the canistered waste forms be accurate within 15%. This will be generically addressed in the Waste Form Qualification Report so that it will not need to be routinely addressed in the Production Records. If the scheme outlined above is followed, then the heat generation rates should have the required accuracy.

FIGURE 5.450.1 Tasks planned to satisfy Specification 3.7.2, Heat Generation During Production

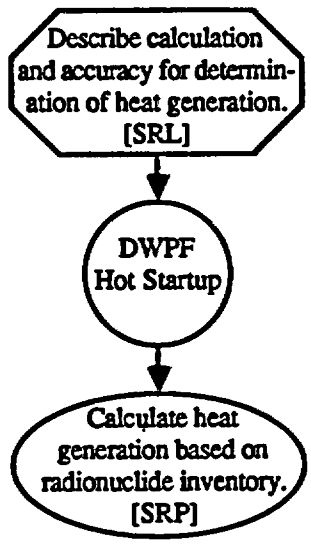
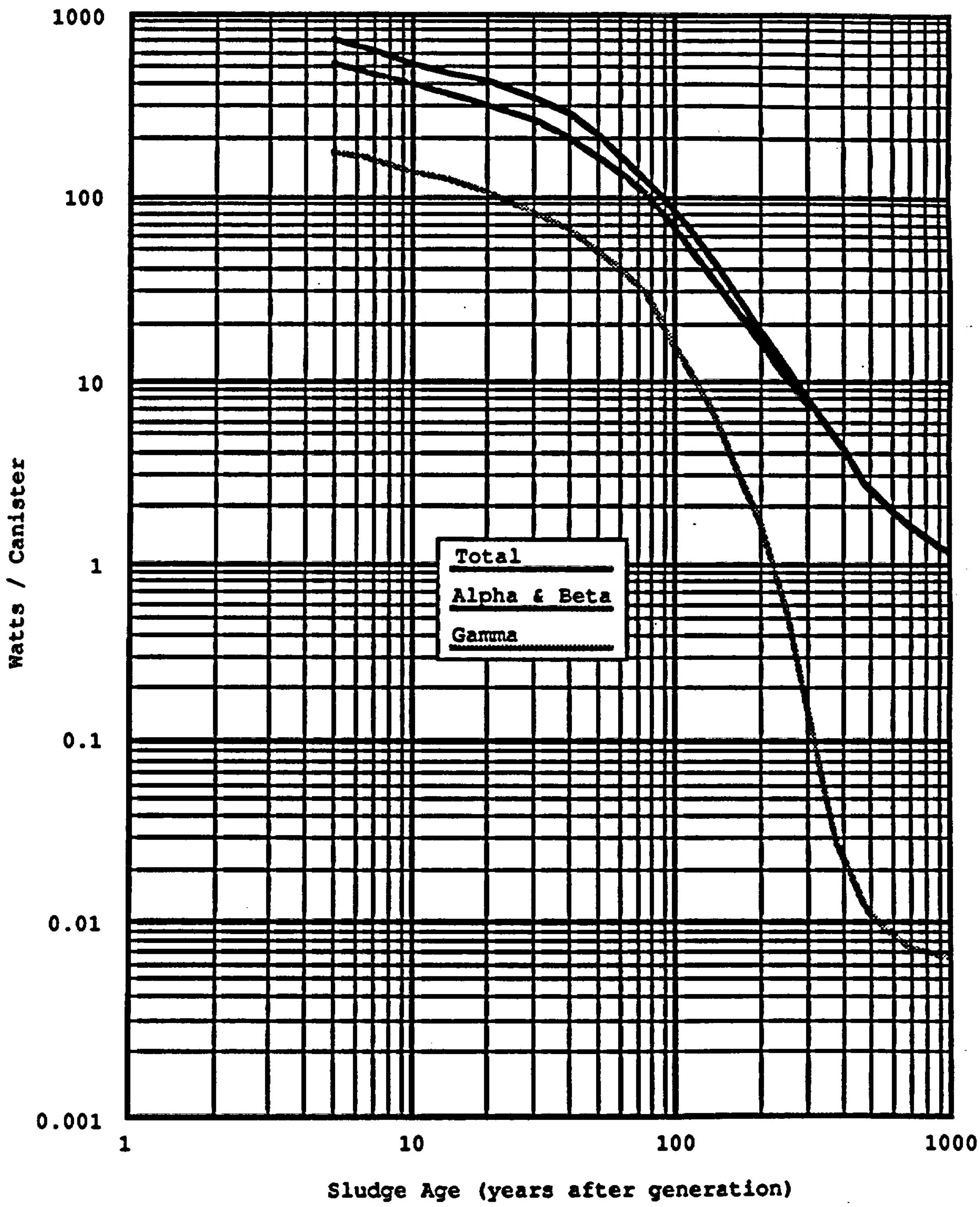


FIGURE 5.450.2 Heat Generation Rate of Design-Basis DWPF Canistered Waste Form



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.1 PROJECTIONS OF MAXIMUM DOSE RATES

3.8 SPECIFICATION FOR MAXIMUM DOSE RATES

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

3.8.1 Projections of Maximum Dose Rates

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

Rationale

The repository projects need the maximum gamma and neutron dose rates in order to design shielding for the receipt and handling facilities. The value of 105 rem/hr for maximum gamma dose rate and 103 rem/hr for maximum neutron dose rate provide a reasonable basis for repository design and operation and are judged to be sufficiently above the expected dose rates for DWPF waste forms to provide reasonable flexibility for normal operations.

Compliance Strategy

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

Implementation

As shown in Figure 5.500.1, 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

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.1 PROJECTIONS OF MAXIMUM DOSE RATES

waste forms have already been made. These have been calculated from the composition and radionuclide inventory of the design-basis waste glass. Both gamma and neutron dose rate calculations have been performed by independent means to verify the calculations.

Table 5.500.1 compares calculations of the gamma radiation from DWPF canistered waste forms by four different codes and companies. The SRP calculation was made using the "ANISN" and "QAD" Codes, the GA Technologies calculation was made using the "PATH" Code, the Westinghouse calculation used the "SCAP" and ANISN-W Codes, and the Bechtel, Inc., calculation used GRACE-II. All four codes use point kernal integration techniques, and are based upon similar waste glass formulations. As can be seen, the calculations agree within a factor of two. The calculation scheme used for the DWPF dose rate projections will be validated using actual SRP waste glass.

Table 5.500.2 provides a limited comparison of calculations of the neutron radiation from a DWPF canistered waste form by three different methods. The calculations differ by a factor of less than 2. The SRP calculation has been experimentally verified using simulated waste glasses doped with plutonium and curium.

Documentation

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.

TABLE 5.500.1 Comparison of calculations of gamma dose rates of DWPF canistered waste forms

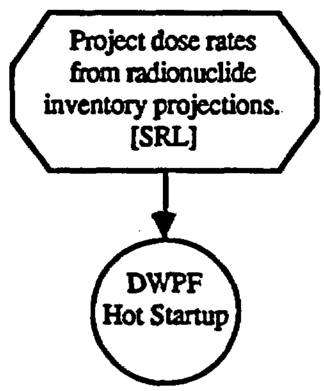
Distance From Canister Surface (ft)	SRP (ANISN/ QAD-CG) (R/hr)	GA (PATH) (R/hr)	Westinghouse (SCAP/ ANISN-W) (R/hr)	Bechtel (GRACE-II)* (R/hr)
0	5570	7600	11300	10970
1	2190	3500	4500	4760
2	1600	2180		2885
3	900	1500	1860	1920
4	690	1070		1350
5	470			990
7	290	490		590
10	160	270		320
15	75	130		155
20	44			89
30	20	34		40
50	7	12		14
75	3	5		6
100	2	3		3

*Calculational code method used.

TABLE 5.500.2 Comparison of calculations of neutron dose rates of DWPF canistered waste forms

Distance from Canister Surface (ft)	SRP (ANISN) (mrem/hr)	GA (DTF) (mrem/hr)	Westinghouse (ORIGEN/SOURCES/ANISN/WEST) (mrem/hr)
0	420	250	305
1	97		
3	42		
5	23		
10	7.5		
20	2.5		
30	1.0		
50	0.5		

FIGURE 5.500.1 Tasks planned to satisfy Specification 3.8.1, Projections of Maximum Dose Rates



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.8.2 MAXIMUM DOSE RATES DURING PRODUCTION

3.8 SPECIFICATION FOR MAXIMUM DOSE RATES

3.8.2 Maximum Dose Rates at Time of Shipment

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

Compliance Strategy

The gamma and neutron dose rates of each canistered waste form will be measured prior to shipment from the DWPF.

Implementation

The WAPS require that the DWPF report, in the Production Records, the gamma and neutron dose rates for the canistered waste forms, at time of shipment. During production, these will be measured just before the canistered waste form is transferred from the vitrification building to the interim storage building. At time of shipment, these will be measured again in the DWPF shipping facility.

If the calculated dose rates exceed 10^5 R/hr surface gamma dose rate, or 10^3 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 800. However, the values of the gamma and neutron dose rates in Table 5.550.1 should be upper bounds for the actual gamma and neutron dose rates. As the table shows, most of the dose rate is due to gamma radiation.

Documentation

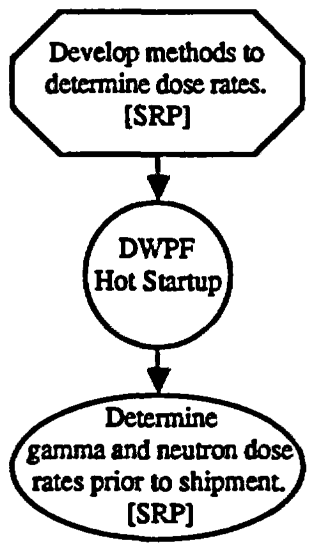
The Waste Form Qualification Report will include a description of the equipment for measuring the gamma and neutron dose rates.

The Production Record for each canistered waste form will include the gamma and neutron dose rates of the canistered waste form as determined prior to shipment from the DWPF.

TABLE 5.550.1 Dose rates from DWPF design-basis canistered waste forms

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

FIGURE 5.550.1 Tasks planned to satisfy Specification 3.8.2, Maximum Dose Rates during Production



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.9 CHEMICAL COMPATIBILITY SPECIFICATION

3.9 CHEMICAL COMPATIBILITY SPECIFICATION

The contents of the canistered waste form shall not lead to internal corrosion of the canister such that there will be an adverse effect on normal handling during storage, transportation, and repository operation. The producer shall describe the method of compliance in the WCP and document in the WQR the extent of corrosiveness and chemical reactivity among the waste form, the canister, and any filler materials. Corrosion, chemical interactions, and any reaction products generated within the canistered waste forms after exposure to temperatures up to the transition temperature of Specification 1.4(a) shall be evaluated in the WQR.

Rationale

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

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 lead to significant internal corrosion of the canister, as long as liquid water is excluded from the canistered waste form. Controls are being implemented to prevent liquid water from entering the canistered waste form, as described in Part 5, Item 100.

Implementation

This specification is intended to assure that the waste package can be safely handled during storage at SRP, and during transport to the repository. It is also intended to provide data concerning the projected long-term integrity of the canister. The tasks planned to satisfy this specification are outlined in Figure

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ITEM TITLE: 3.9 CHEMICAL COMPATIBILITY SPECIFICATION

5.600.1. These include:

- Evaluation of the chemical compatibility of 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.

- Determination of the threshold limits for all extraneous non-glassy substances.

Evidence currently available indicates that internal corrosion is unlikely if liquid water is excluded from the canister. All materials present in the canistered waste form will be identified, and threshold limits for extraneous (non-waste glass) materials will be determined. Controls are being developed to prevent these threshold limits from being exceeded. Once developed, these controls will be implemented in the DWPF.

- Determination of the effects of exposure of the canistered waste form to temperatures up to T_g on the compatibility of the canister and its contents

It is anticipated that there will be insufficient information in the literature to satisfy this requirement. Thus, exposure of simulated canistered waste forms to temperatures up to T_g will be required. After the canistered waste form is exposed to the transformation temperature, T_g, any corrosion or reaction products will be identified.

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 SRP, during transport to the repository, or during the retrievability period.[1]

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ITEM TITLE: 3.9 CHEMICAL COMPATIBILITY SPECIFICATION

Tests have been made exposing sensitized metal coupons to molten glass. Figure 5.600.2 shows the test design. After testing, the metal specimens were mounted in resin, ground and polished, and then 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 1/40th of those required to assure canister integrity during interim storage at SRP, and during the retrievability period at a repository (assumed to be 100 years).

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.

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).

In order to prevent internal canister corrosion, liquid water must be excluded from the canistered waste form. Administrative controls and canister closure techniques will be used to ensure water penetration is prevented. This problem is addressed in more detail in Part 5, Item 100.

Documentation

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. The WQR will also include a report on the controls to be used to keep liquid water out of the canistered waste form.

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ITEM TITLE: 3.9 CHEMICAL COMPATIBILITY SPECIFICATION

The Production Record for each canistered waste form will certify that appropriate controls were used to prevent the introduction of liquid water into the canistered waste form, as described in Part 5, Item 100.

References

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

FIGURE 5.600.1 Tasks planned to satisfy Specification 3.9, Chemical Compatibility Specification

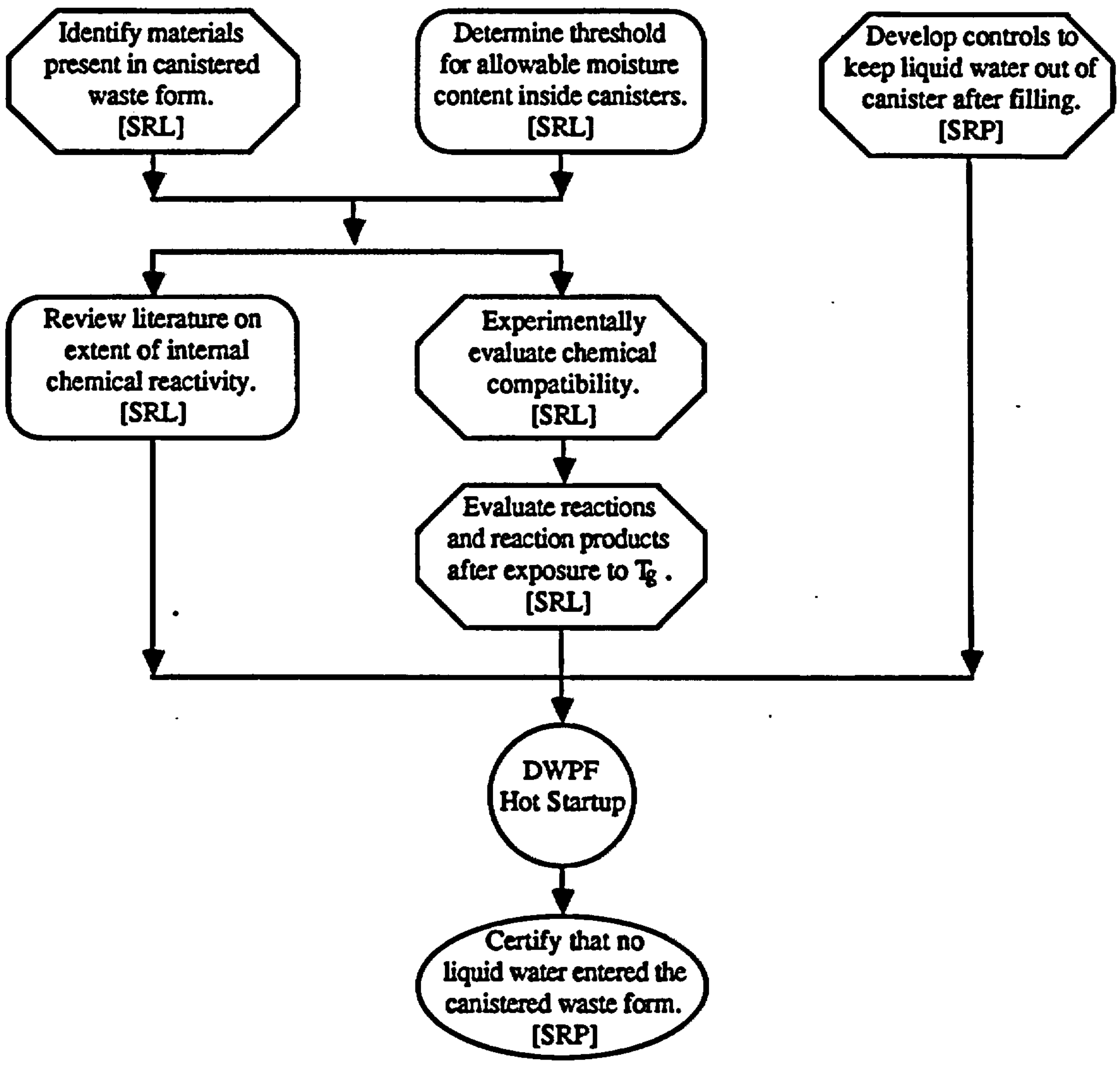
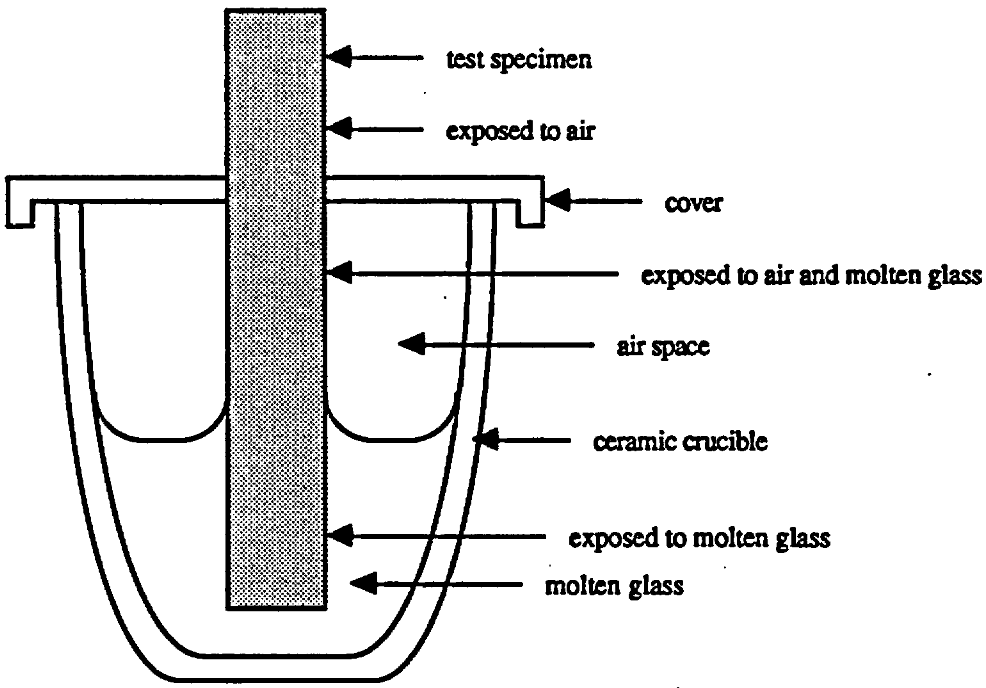


FIGURE 5.600.2 Experimental design of long-term corrosion tests



PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

3.10 SUBCRITICALITY SPECIFICATION

The producer shall ensure that the canistered waste form will remain subcritical under all credible conditions likely to be encountered from production through receipt at the repository. The calculated effective neutron multiplication factor, k_{eff}, shall be sufficiently below unity to show at least a 5 percent margin after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation. The producer shall describe the method of compliance in the WCP and provide supporting documentation in the WQR. The WQR shall also include sufficient information on the nuclear characteristics of the canistered waste form to enable the repository designer to confirm subcriticality under repository storage and disposal conditions.

Rationale

The regulatory requirements as outlined in 10 CFR 60.131 (b)(7) state that, "The calculated effective multiplication factor k_{eff} must be sufficiently below unity, to show at least a 5 percent margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to evaluate the method of calculation."

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

Compliance Strategy

A bounding calculation will be performed to show that the effective multiplication factor of 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. This specification requires that the neutron multiplication factor of the waste form remains much less than 1 for

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

all conditions it will encounter. 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. An infinite amount of material was assumed in the calculations.

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.

The calculations were repeated recently for three glass compositions which represent those expected to be produced in the DWPF during the first six 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 uniform in composition and infinite in amount.

For the Batch 1, 2 and 3 glasses the calculated values of k_∞ 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_∞ for Batch 1, 2, and 3 to 0.0026, 0.0081, and 0.0092, respectively. These values of k_∞ provide ample margin for uncertainties.

The calculated values of k_∞ 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_∞ to exceed a critical value without introducing

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ITEM TITLE: 3.10 SUBCRITICALITY SPECIFICATION

at least two orders of magnitude more fissile isotopes.

Documentation

The Waste Form Qualification Report will include a report on the calculation 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.

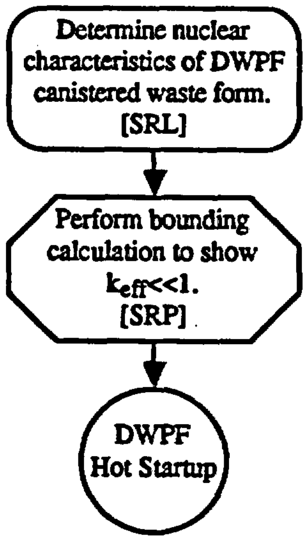
References

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).

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, LENGTH, DIAMETER, AND OVERALL DIMENSIONS

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

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

3.11.1 Weight Specification

The weight of the canistered waste form shall not exceed 3000 kg. The measured weight shall be reported in the production records, accurate to within ±5%.

3.11.2 Length Specification

The overall length of the final canistered waste form at the time of shipment shall be 3.000 m (+.005 m, -.020 m).

3.11.3 Diameter Specification

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

3.11.4 Specification for Overall Dimensions

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

Rationale

The specifications on weight, length, diameter and wall thickness of the canistered waste form are needed for the

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repository design of handling requirements and waste packages. The overall dimensions of the canistered waste form must be such that (1) no forcing is required to place it in the disposal package container to prevent damage to the inside of the container and (2) there is compatibility with container geometry.

Compliance Strategy

The final weight of each canistered waste form will be measured prior to shipment from the DWPF to a repository. The dimensions of the canister will be controlled by the canister manufacturer, but will be measured prior to shipment. Any effects of the vitrification process on the length, diameter, or wall thickness will be determined from measurements of non-radioactive canistered waste forms produced under conditions representing the range of those expected in the DWPF. Data currently available indicate that the minimum wall thickness will be 0.89 cm, and the average wall thickness will be 0.95 cm. 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 5.700.1. The actions taken initially include:

- Development of requirements for the canister length, diameter, and wall thickness which have been included in the canister procurement specifications.

- Determination of the additional length due to the weld plug (0.2 cm) or due to a repair weld cap.

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

Seven prototypical DWPF canisters were carefully measured, and then filled with glass at the DWPF pilot plant facility under both design basis and possible upset conditions. These canisters were then remeasured to determine the effects of canister filling on canister dimensions. It was anticipated that any detectable deformation would be manifested as either bulging of the canister

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wall, which would effect the diameter measurement, or as bow in the upright canister, which would prevent the canister from fitting correctly into the specified right-circular, cylindrical cavity. Figure 5.700.2 contains a diagram of the canister indicating measurement locations, and the mean and standard deviation 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, 60.96 ± 0.06 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: 0.20 ± 0.12 cm). Since the process induced dimensional changes are slight; it is very important to ensure the procured canister conforms to the specifications, as compliance is governed by this controlling factor.

The weights of the canistered waste forms were measured; the average weight was 3,718 ± 115 pounds of glass. Thus, the total weight of each simulated canistered waste form was less than 75 % of the maximum specified weight, indicating that the DWPF should have little difficulty in meeting the weight specification.

Documentation

The Waste Form Qualification Report will include a report on the canister procurement and inspection procedures to be used to ensure control of the length, diameter, and wall thickness. The WQR will also include a report on the effect of the vitrification process on the canistered waste form dimensions.

The Production Record for each canistered waste form will include the length and diameter of the canistered waste form. The Production Record for each canistered waste form will also include the weight and a determination of the cylindricality. The weight will be obtained from load cells in the Melter Cell, and confirmed by weighing in the shipping facility. The diameter and length will be reported based on measurements of the canistered waste form prior to shipment from the DWPF. The bow of the glass-filled canisters will either be measured directly, or will be certified based on the ability of the canister to fit, without forcing, into the shipping cask or a template of the cask.

The WAPS also require that the DWPF certify, in the Production

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Records, that the reported weight of canistered waste forms be accurate within 5%. Thus, the load cells used to determine the canistered waste form's weight will be calibrated, and certified accurate within 5%. The WAPS do not require that evidence of their calibration be reported, but this evidence will be contained in the detailed records of canistered waste form production.

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

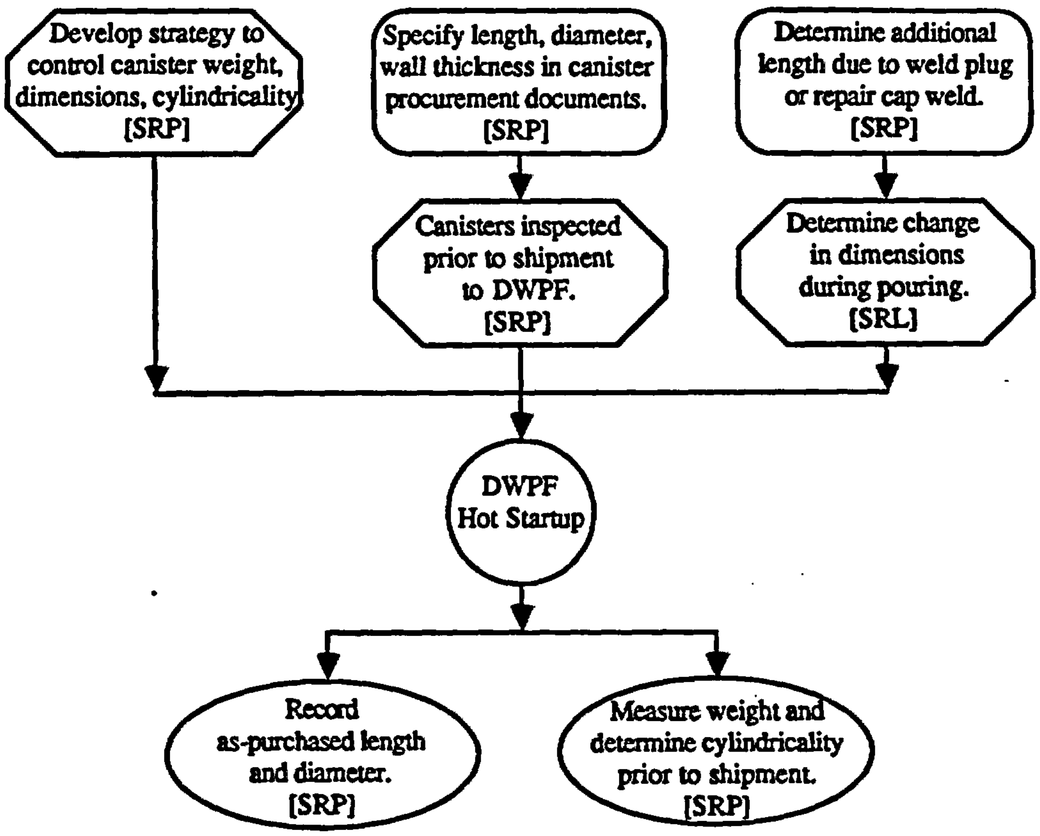
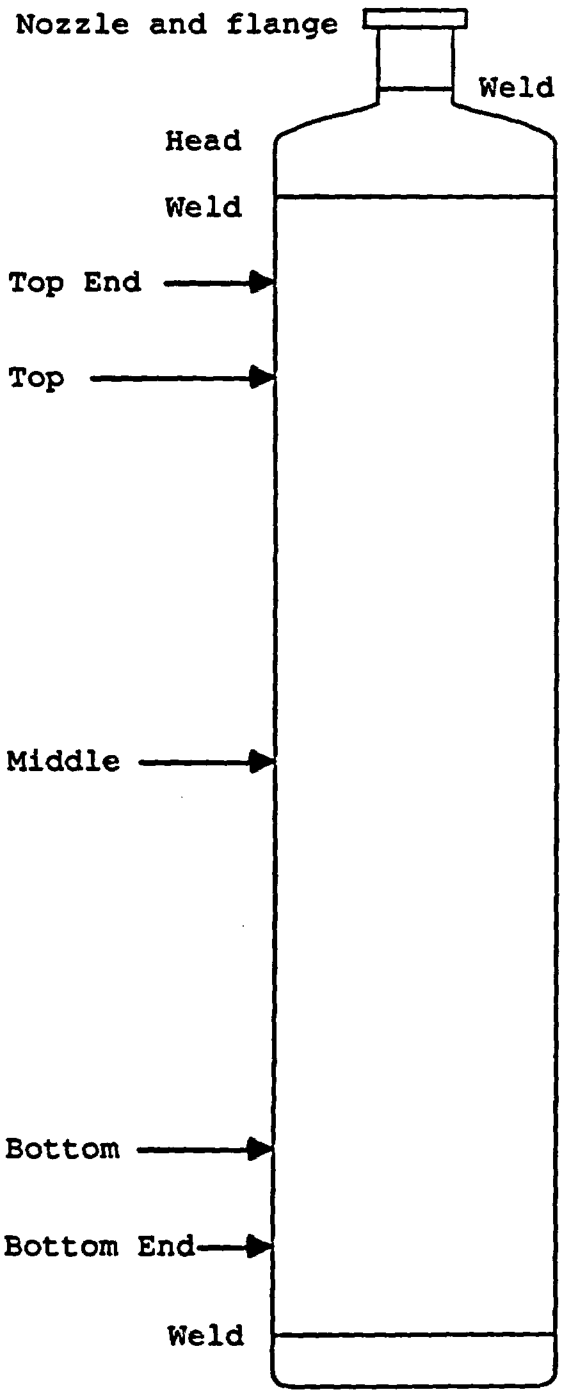


FIGURE 5.700.2 Components and dimensions of DWPF canisters filled under design-basis and possible upset conditions in pilot plant tests (calculated for all canisters)



	$\bar{x}$	$\pm\sigma$
Overall length	299.64	0.16 cm
Outside diameter	60.96	0.06 cm
Flange tilt	0.63	0.33°
Upper head mismatch	0.264	0.20 cm
Lower head mismatch	0.198	0.34 cm
Bow (middle)	0.019	0.15 cm
Bow (top)	0.076	0.19 cm
Average deformation after filling	0.05	0.06 cm
Maximum deformation after filling	0.20	0.12 cm
Average wall thickness	0.95 cm	
Minimum wall thickness	0.89 cm	

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.12 DROP TEST SPECIFICATION

3.12 DROP TEST SPECIFICATION

The canistered waste form at time of shipment shall be capable of withstanding a drop of 7 m onto a flat, essentially unyielding surface without breaching. The producer shall describe the method of compliance in the WCP and present the supporting documentation of analysis and test results in the WQR. The test results shall include information on measured canister leak rates and canister deformation after the drop test.

Rationale

This specification is intended to demonstrate that the canistered waste form can withstand severe physical impact without breaching. By requiring that the canistered waste form pass a performance (drop) test without breaching, this specification obviates the need for the alternative approach of establishing detailed specifications on the material properties of the canister and the waste form necessary to describe the radionuclide source term associated with the possible breach of a canister as a result of a drop accident. The drop height of 7 m was chosen as representative of the maximum drop height under normal operating conditions. The surface which is characteristic of normal operating conditions has been defined as a "flat, essentially unyielding" surface.

Compliance Strategy

Non-radioactive (simulated) canistered waste forms will be prepared under design-basis conditions. These will then be drop-tested, and the results reported in the Waste Form Qualification Report.

SRL has also transported prototypical canisters from SRL to the Waste Isolation Pilot Plant (WIPP) in New Mexico, and emplaced them in a hot (ca. 120°C) salt environment. These canisters will be retrieved, returned to Savannah River. The effects of transport, emplacement, and retrieval on the canister and canistered waste form will be determined.

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ITEM TITLE: 3.12 DROP TEST SPECIFICATION

Implementation

The Savannah River Laboratory 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. Based on this previous experience, the current DWPF canister design should be able to survive the less severe impact called for in the specification.

The tasks planned to satisfy this specification are outlined in Figure 5.750.1. Canisters of the current DWPF design have been procured for SRL by the DWPF, according to the current canister specifications (see Part 4, Items 100 and 200). These have been filled at both design-basis and likely upset conditions, to the same levels expected for DWPF canisters (see Part 5, Item 300). These canisters have been sealed in the same manner as in the DWPF (in some cases, with actual DWPF equipment). These will be dropped from 7 m, and tested by dye penetrant methods. He leak rates will also be determined. Canisters will be dropped in two orientations:

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

Canisters will have strain circles applied to determine the magnitude of the strains on the canisters. After the initial testing is completed, a few of the canisters will be repeatedly dropped to determine how many such impacts the canister could withstand before breaching.

SRL has also filled canisters under expected process conditions, and transported them to the Waste Isolation Pilot Plant (WIPP) in New Mexico. These canisters were emplaced in a hot (ca. 120°C) salt environment, for materials compatibility testing.[2-5] These canisters will be retrieved, returned to Savannah River. The effects of transport, emplacement, and retrieval on the canister and canistered waste form will be determined.

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ITEM TITLE: 3.12 DROP TEST SPECIFICATION

Documentation

The Waste Form Qualification Report (WQR) will include a report on the results of the drop tests, and will report on the effects of impacts on the canister's ability to fulfill its function if dropped. The effects of transport, emplacement, and retrieval on the canister and canistered waste form will also be reported, based on the WIPP tests.

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).

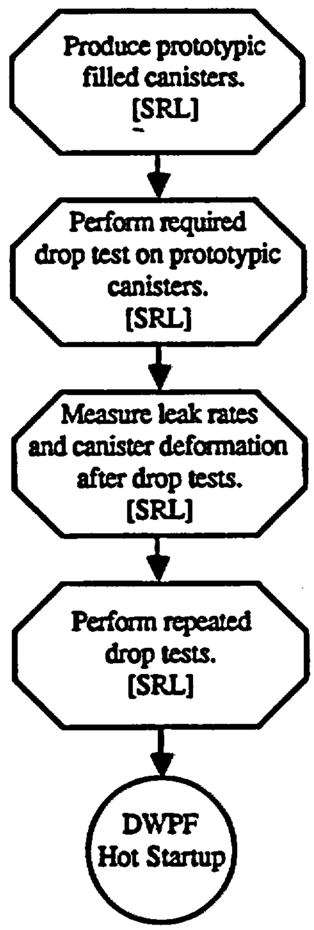
2. R. V. Matalucci, C. L. Christensen, T. O. Hunter, M. A. Molecke and D. E. Munson, **Waste Isolation Pilot Plant Research and Development Program: In Situ Testing Plan**, USDOE Report SAND81-2628, Sandia National Laboratory, Albuquerque, NM (1982).

3. M. A. Molecke, "WIPP Waste Package Testing on Simulated DHLW: Emplacement," **Scientific Basis for Nuclear Waste Management**, C. M. Jantzen, J. A. Stone and R. C. Ewing (eds.), 265-71 (1985).

4. G. G. Wicks, **WIPP/SRL In-Situ and Lab Testing Programs-Part I: MIIT Overview, Nonradioactive Waste Glass Studies**, USDOE Report DP-1706, E. I. DuPont de Nemours, Inc., Savannah River Laboratory, Aiken SC (1986).

5. M. A, Molecke and R. Beraun, "WIPP Simulated DHLW Tests: Status and Initial In Situ Backfill Thermal Conductivities," **Waste Management 86, 2**, Roy G. Post (ed.), 231-36 (1986).

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 neck with a lifting flange. The lifting flange geometry and maximum loading capacity shall be described in the WCP. The producer shall design the lifting flange and a suitable grapple, which could be used at the repository. The grapple and the flange shall be designed to satisfy the following requirements:

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

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

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

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

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ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

Rationale

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

Compliance Strategy

The strategy for compliance with this specification is to supply designs of the canister flange and grapple, and to provide test data to the repository. Testing of these designs have shown that they will meet the specification.

Implementation

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

One of the initial actions taken to satisfy this specification was to design the canister lifting flange. The lifting flange geometry for the DWPF canister is shown in Figure 5.800.2; more detail is available from DuPont drawing #W747391, revision 11, including method of attachment to the canister. A detailed design drawing of the lifting flange is incorporated in the canister procurement specifications.

The canister lifting grapple is specific for the DWPF canister and was developed by Remote Technology Corp. (REMOTEC) of Oak Ridge, TN.[1] The design is described in detail in the reference, so only the principles are described here. A photograph of an assembled unit used for testing is shown in Figure 5.800.3.

- Maximum size — Diameter = 600 mm; Length = 1000 mm
- Capacity — 6,820 kg, rated
- Operation — Two step release, failsafe. Transported by in-cell crane.

PART TITLE: CANISTERED WASTE FORM SPECIFICATIONS

ITEM TITLE: 3.13 HANDLING FEATURES SPECIFICATION

• Mechanism	All mechanical.
• Design Life	60,000 cycles over 5 years without lubrication.
• Repair	Contact maintenance after high pressure wet decontamination.
• Failure Recovery	Manual release activated by 4 kg maximum pull force.
• Materials	Structural: 304L stainless steel. Sliding contact: Nitronics 50 or 60. Bolting: 304 stainless steel bolts, 410 stainless steel nuts.
• Testing	Load test: 125% of rated load Cycle test: 500 cycles at rated load Misalignment: Engage canister neck with 25 mm off-set from grapple centerline. Collision: Strike object with crane traveling at 9 m/min.

Documentation

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 will be included as well.

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).

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

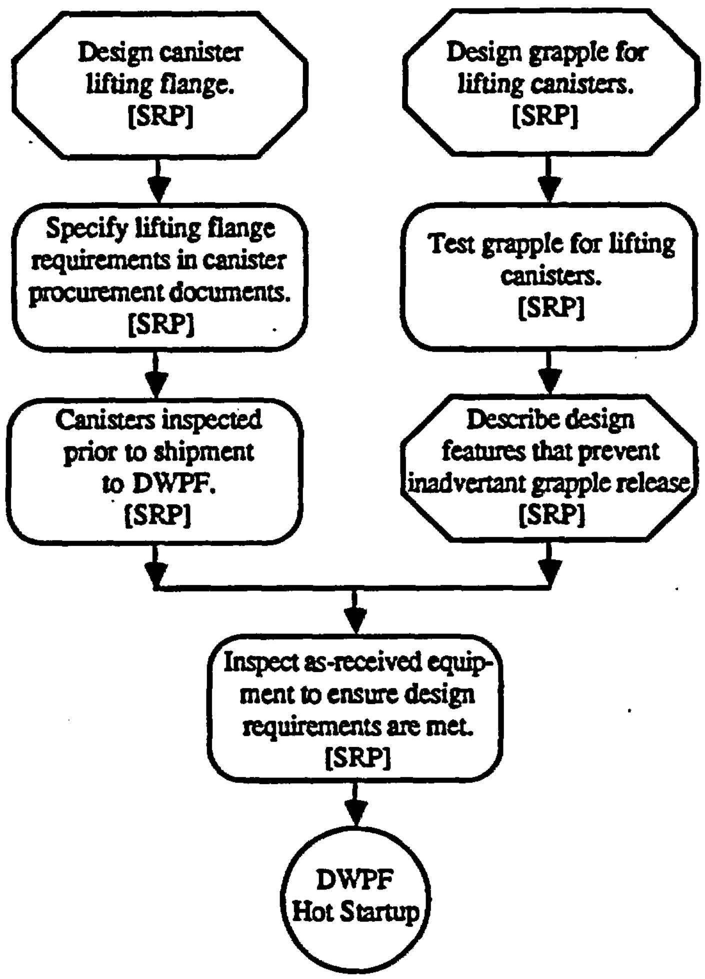


FIGURE 5.800.2 Lifting Flange Geometry for DWPF Canisters

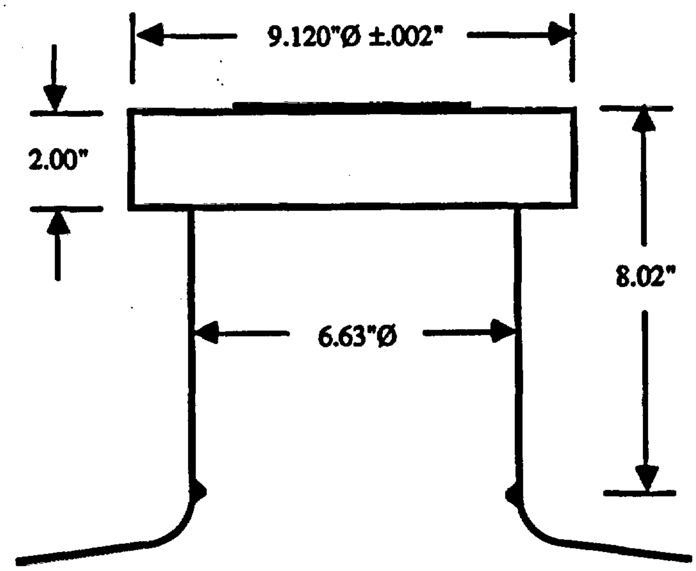
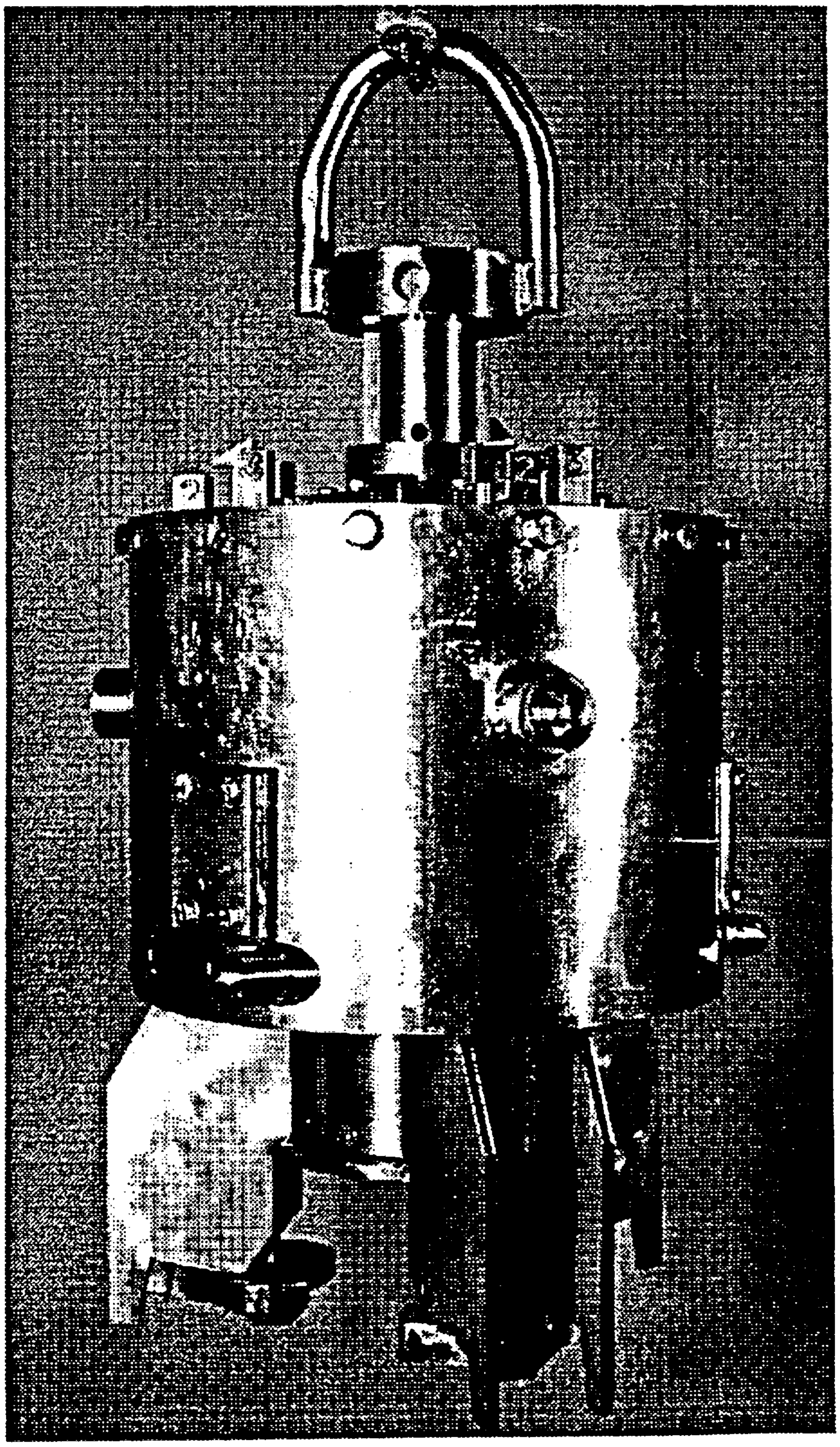


FIGURE 5.800.3 DWPF Canister Grapple



PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE SPECIFICATION

4. QUALITY ASSURANCE SPECIFICATION

The producer shall establish, maintain, and execute a quality assurance (QA) program that complies with OGR/B-14, Quality Assurance Requirements for High-Level Waste Form Production. The quality assurance program shall be applied to all testing and analysis activities that provide information to be included in WQRs. The WCPs shall be prepared in accordance with the QA program; however, existing data generated prior to the inception of the subject QA program may be included in the WCP so long as the specific QA measures that were in effect when the data were generated are described. The quality assurance program shall also be applied to all activities that affect compliance with waste acceptance specifications during waste form production, handling, storage, preparation for shipment, and shipment to the repository. The producer shall describe his QA program in the WCP and certify compliance with it in the WQR, and in production records.

Compliance Strategy

When the Waste Acceptance Preliminary Specifications (WAPS) were first issued (12/86), both the DWPF and the repository programs recognized that direct application of the repository program's quality assurance program was not possible, because the program documentation did not clearly reflect the relationship between the DWPF and the repository program. In particular, the documentation did not contain any reference to the Waste Acceptance Process, or to the WAPS. Thus, the mode of application of these documents to the DWPF's Waste Acceptance Process activities needed clarification. For this reason, SRP - DWPF and SRL, working with the Office of Civilian Radioactive Waste Management, have developed detailed quality assurance requirements for DWPF Waste Acceptance Process activities. These have been issued by the repository program as OGR/B-14.

The strategy for compliance with this specification is, thus, to develop the requirements, and then to develop and implement a quality assurance program which will satisfy them. Once developed, a description for this quality assurance program will be prepared, as called for in the WAPS.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE SPECIFICATION

Implementation

The tasks planned to satisfy this specification are outlined in Figure 6.100.1. They include the following:

- SRP - DWPF and SRL, working with the Office of Civilian Radioactive Waste Management, will develop detailed quality assurance requirements for DWPF Waste Acceptance Process activities.

- SRP - DWPF and SRL will approve the draft Waste Form Compliance Plan, in writing, and send it to DOE - SR for review and approval. DOE - SR will then be responsible for transmittal of the draft WCP to other DOE organizations, as appropriate.

- Responsibility for implementation of the Waste Form Compliance Plan will be assigned by SRP - DWPF.

- A quality assurance program for DWPF Waste Acceptance Process activities, performed by either SRP - DWPF or its supporting organizations, will be developed.

- A description of the quality assurance program will be prepared for inclusion in the Waste Form Compliance Plan.

- Procedures will be prepared which implement the quality assurance program.

Each of the quality assurance requirements in OGR/B-14 are being addressed during development of the quality assurance program for the DWPF. A description of this program is also being prepared. SRP - DWPF will then implement the quality assurance program for the DWPF, which will ensure the quality of the canistered waste forms delivered to a federal repository, and compliance with the quality assurance requirements.

All organizations providing support to SRP - DWPF in performance of Waste Acceptance Process activities (for example, SRL) will establish quality assurance programs which conform with this program description. SRP - DWPF will be responsible for oversight of these programs to ensure the conformance of the supporting organizations.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE SPECIFICATION

The quality assurance program described will thus apply to:

• All Waste Acceptance Process activities, as described in the Waste Form Compliance Plan, or its revisions (for the procedure proposed for such revisions, see Part 6, Item 700).

• Other actions which directly support those Waste Acceptance Process activities, for example: calibration of measuring and test equipment, control of procurement, and control of documents. All support activities which affect the acceptability of the canistered waste form will be subject to this quality assurance program.

Development and implementation of the quality assurance program will be the responsibility of SRP - DWPF. The quality assurance program will be reviewed and approved by the SRP - DWPF line organizations. A description of the program will be prepared by SRP - DWPF for inclusion in the WCP, and then transmitted to DOE - SR for review, and distribution to other DOE offices as appropriate.

The program description will describe 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.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE SPECIFICATION

Work performed under this quality assurance program will be periodically reviewed by the line organization responsible for the activity. These reviews will be augmented by periodic independent audits. The quality assurance program will recognize that these independent audits 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. The quality assurance program will specify the minimum frequency of such audits and reviews.

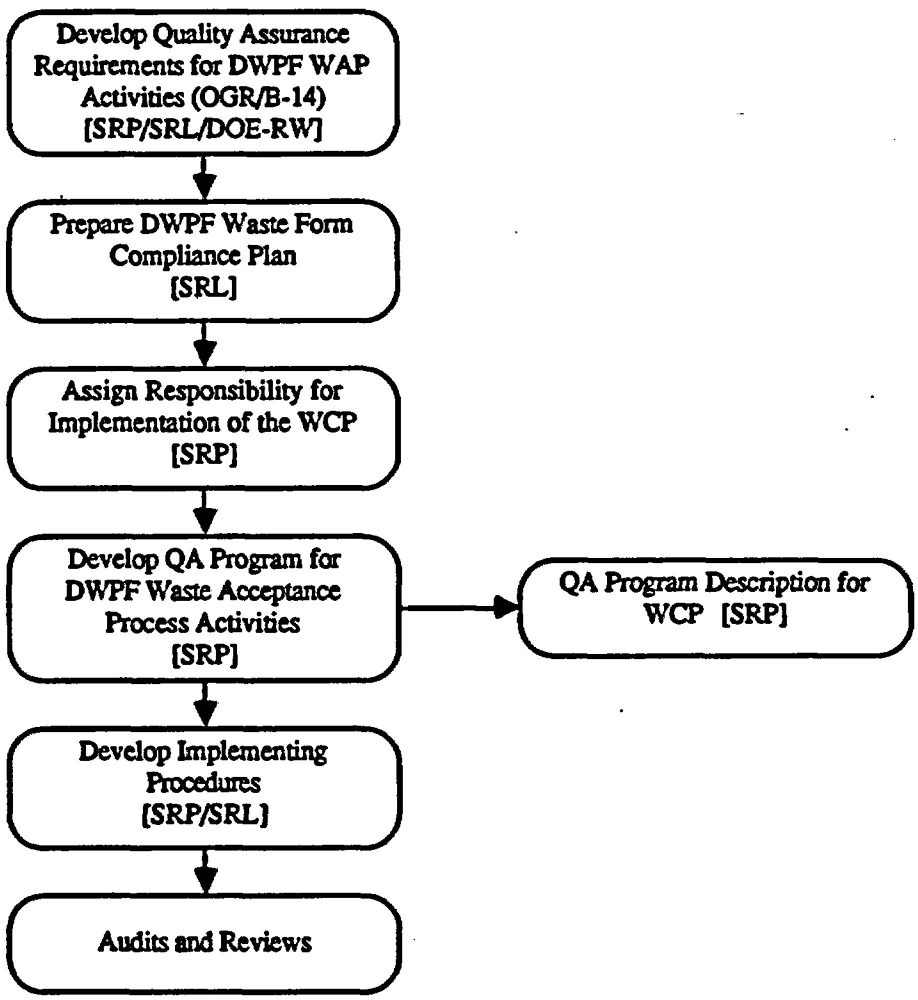
Documentation

The detailed quality assurance requirements for Waste Acceptance Process activities are contained in OGR/B-14. A description of the quality assurance program which ensures that these requirements are met will be prepared, and appended to the WCP.

Reference

1. DOE-OCRWM Specification, "Quality Assurance Requirements for High-Level Waste Form Production (OGR/B-14)."

FIGURE 6.100.1 Tasks planned to satisfy Specification 4, Quality Assurance



PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE OF WASTE ACCEPTANCE PROCESS DOCUMENTATION

Facilities to immobilize high-level radioactive waste in borosilicate glass will begin operation before the first repository presents its license application. As is described in Part 1, Item 100, the Department of Energy has set up a Waste Acceptance Process to ensure that glass waste forms will be acceptable at a federal repository. The present Waste Acceptance Preliminary Specifications were prepared by a working group (the Waste Acceptance Committee), made up of representatives of the repository projects, and of potential waste form producers. The members of this group, and the organizations represented, are listed in Table 6.200.1. Thus, the detailed specifications leading to the acceptance of DWPF glass have been reviewed by the repository projects, and the waste producers. In addition, the Waste Acceptance Preliminary Specifications (WAPS) have also been reviewed by the Nuclear Regulatory Commission's staff.

The WAPS require that the DWPF provide the repository program with three types of documentary evidence for acceptance of the DWPF waste form: a Waste Form Compliance Plan, a Waste Form Qualification Report, and Production Records.

Each of these will be prepared in a manner which will address each of the applicable quality assurance requirements in OGR/B-14. The Waste Form Qualification Report and the Production Records will be prepared in accordance with the quality assurance program for DWPF Waste Acceptance Process activities. This quality assurance program will be designed to satisfy the requirements of the Savannah River's Site Quality Assurance Plan, the quality assurance requirements for Waste Acceptance Process activities (OGR/B-14), and the Waste Acceptance Preliminary Specifications.

The first form of documentary evidence is the Waste Form Compliance Plan (WCP). This has been prepared for the DWPF by the Savannah River Laboratory, in accordance with the Savannah River Laboratory's quality assurance program, which conforms to ANSI/ASME Standard NQA-1. The WCP includes the detailed quality assurance requirements for Waste Acceptance Process activities, as well as a description of the quality assurance program developed to satisfy these requirements (see Part 6, Item 100). The overall logic of the WCP has been reviewed by DOE - SR's DWPF Project Office, and the Office of Civilian Radioactive Waste Management's Waste Acceptance Committee. The Nuclear Regulatory Commission is also ex-

pected to review the WCP, before it is baselined by the repository programs.

For each of the tasks identified in the Waste Form Compliance Plan, detailed requirements for acceptance of the results of the task will be prepared. For many tasks, technical program plans and procedures will be required. Each will be prepared in accordance with the DWPF quality assurance program for Waste Acceptance Process activities. Acceptance requirements, and any technical program plans and procedures, will be reviewed by the organization assigned responsibility for implementation of the WCP. In addition, many of the technical program plans and procedures will be reviewed by independent technical peers.

The Waste Form Qualification Report (WQR), the second form of documentary evidence called for by the WAPS, will detail the work performed to establish the acceptability of the DWPF product. The SRP - DWPF will be responsible for preparation of this document, in accordance with the DWPF quality assurance program for Waste Acceptance Process activities. The WQR will be reviewed by DOE - SR, and by the Office of Civilian Radioactive Waste Management. The portions of this document completed before the initiation of radioactive operations will be used to provide DOE with reasonable assurance that DWPF canistered waste forms will be acceptable at a federal repository.

After production of actual canistered waste forms begins in the DWPF, addenda to the WQR will be issued as appropriate. These will include information generated during radioactive operations which is of a more general nature than that included in the Production Records. These addenda will be subject to the same review process as the rest of the WQR.

The Production Records will summarize the detailed record of the production history of individual canistered waste forms produced in the DWPF. They will establish the acceptability of the canistered waste forms actually produced in the DWPF. They will be reviewed by the repository operator before shipment of the canistered waste forms to the repository for disposal. Their content is described in Appendix 1.200.1.

The relationship, in terms of quality assurance, among the various

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: QUALITY ASSURANCE OF WASTE ACCEPTANCE PROCESS DOCUMENTATION

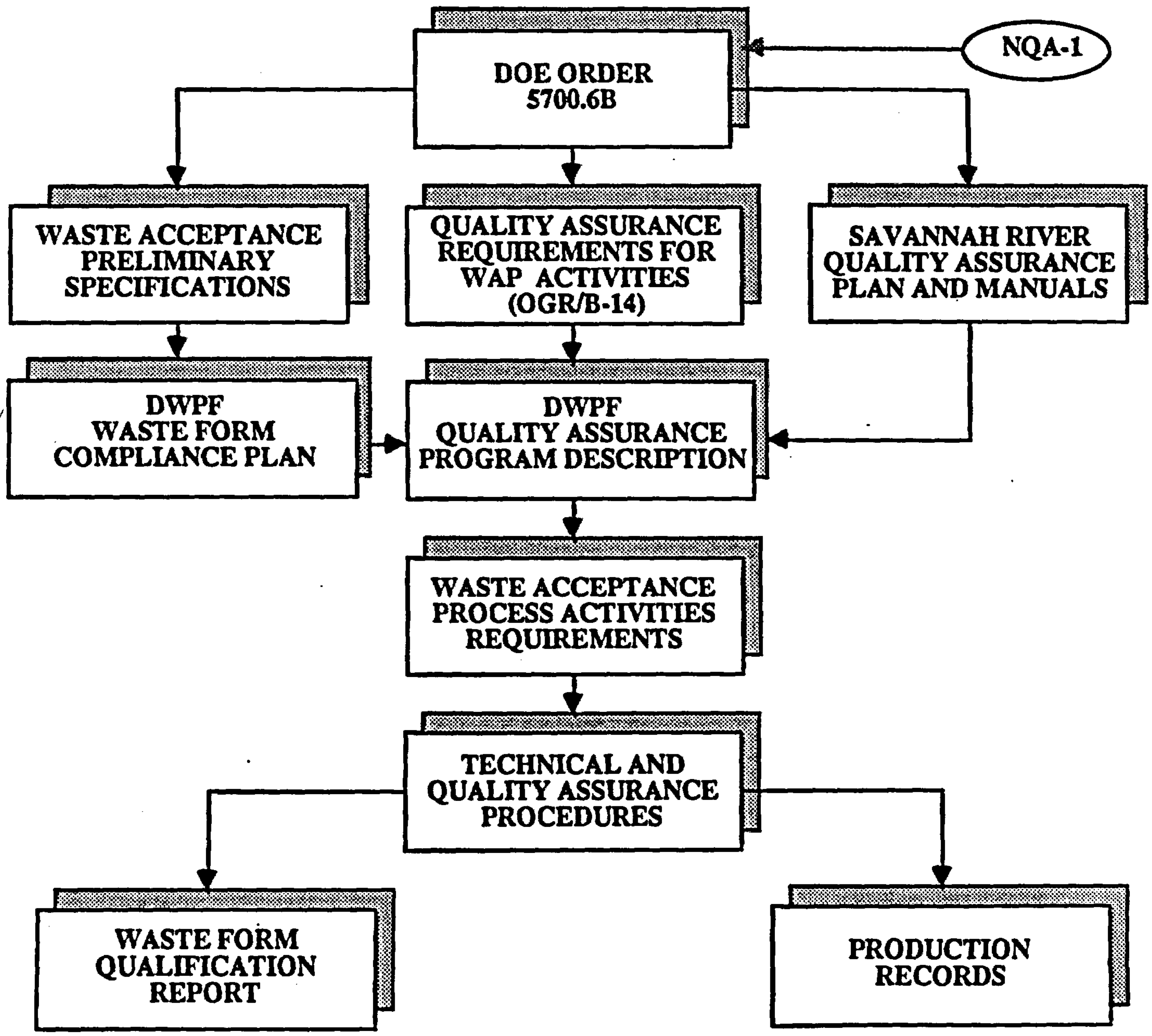
forms of Waste Acceptance Process documentation is shown in Figure 6.200.1.

TABLE 6.200.1 MEMBERSHIP OF WASTE ACCEPTANCE COMMITTEE DURING DEVELOPMENT OF THE WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

NAME	ORGANIZATION REPRESENTED
K. A. Chacey (chairman)	Office of Civilian Radioactive Waste Management (DOE-RW)
E. L. Benz (secretary)	Roy F. Weston, Inc.
E. H. Randklev	Basalt Waste Isolation Project (BWIP)
V. M. Oversby	Nevada Nuclear Waste Storage Investigation (NNWSI)
J. A. Carr	Salt Repository Project (SRP)
A. A. Bauer	Crystalline Repository Project (CRP)
L. R. Eisenstatt	West Valley Demonstration Project (WVDP)
E. J. Hennelly	Savannah River Laboratory - Defense Waste Processing Facility (SRL - DWPF)
B. A. Wolfe	Hanford Waste Vitrification Project (HWVP)
J. S. Berreth	Westinghouse Idaho Nuclear Co.
H. M. Burkholder	Battelle - Pacific Northwest Laboratories
G. S. Mellinger	Materials Integration Office (MIO)

FIGURE 6.200.1 QUALITY ASSURANCE HIERARCHY OF WASTE ACCEPTANCE PROCESS DOCUMENTATION

Each document is subordinate to the one above it.



PART TITLE: QUALITY ASSURANCE

ITEM TITLE: PROPOSED PROCEDURE FOR CHANGES RELATING TO WASTE ACCEPTANCE PROCESS ACTIVITIES

Under certain circumstances, changes 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 is proposed. This procedure will take effect as soon as the Office of Civilian Radioactive Waste Management concurs with the DWPF Waste Form Compliance Plan.

1. SRP - 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's DWPF Project Office of this need, in writing.

2. SRP - 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. SRP - DWPF will transmit the proposed change and its justification to the Project Office, for review and comment. The Project Office will be responsible for transmittal of the proposed change and its justification to other affected DOE offices (including the Office of Civilian Radioactive Waste Management).

4. SRP - DWPF will disposition any comments received.

5. After approval is received from the Project Office, SRP - DWPF will implement the change.

PART TITLE: QUALITY ASSURANCE

ITEM TITLE: PROPOSED PROCEDURE FOR DISPOSITION OF NONCONFORMING CANISTERED WASTE FORMS

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. The following procedure is proposed to disposition nonconforming canistered waste forms. 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's DWPF Project Office, in writing, of the possible existence of a nonconforming canistered waste form, its identification, and the specifications with which it may not comply.

2. The Project Office will notify the appropriate offices in DOE (including the Office of Civilian Radioactive Waste Management).

3. SRP - DWPF will prepare a written description of the nonconforming item, identifying the specification(s) with which it may not comply, and proposing a disposition that will allow safe shipment and handling of the item at the repository.

4. SRP - DWPF will transmit the disposition plan to the Project Office, for review and comment. The Project Office will be responsible for transmittal of the proposed disposition plan to other affected DOE offices.

5. SRP - DWPF will revise the disposition plan, in response to any comments received.

6. After approval is received from the Project Office, SRP - DWPF will proceed to carry out the disposition plan.

7. SRP - DWPF will certify compliance with the disposition plan in an addendum to the Production Record for the non-conforming 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 disposition plan.

WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

(OGR / B-8)

RW - 0125

FOREWORD

This is the first revision of the baselined document Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-Level Waste Form. This document will continue to be identified as OGR/B-8.

WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS for the Defense Waste Processing Facility High-Level Waste Form

TABLE OF CONTENTS

WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS for the Defense Waste Processing Facility High-Level Waste Form

INTRODUCTION

These Waste Acceptance Preliminary Specifications (WAPS) specify the properties and requirements for the high-level waste (HLW) forms to be produced by the Defense Waste Processing Facility (DWPF) at the Savannah River Plant, South Carolina (herein, the producer).

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

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

Where possible, the WAPS reflect generic requirements; however, in one case (i.e., Specification 1.3, Specification for Radionuclide Release Properties), it is not possible to set a single specification that would be adequate for any repository site. (In this case, producers must demonstrate compliance with repository-site-specific requirements.) The required release properties for the waste form will be based on the overall performance allocation for different parts of the engineered barrier system since containment and isolation requirements are to be met by the total engineered barrier system and not necessarily by the waste form alone. The WAPS require demonstration of compliance via three different docu-

ments, each prepared by the producer and concurred with by the repository projects through the waste acceptance process: (1) the Waste Form Compliance Plan (WCP), (2) the Waste Form Qualification Report (WQR), and (3) Production Records.

The Waste Form Compliance Plan (WCP) is the producer's plan for demonstrating compliance with each specification in the WAPS. The WCP is to include detailed descriptions of the testing, analyses, and process controls to be performed by the producer, including the identification of production records to be provided, to demonstrate compliance with the specifications. The plan for compliance with each specification is to be concurred with by the repository project. To meet schedule demands, it may be necessary for WCP preparation and concurrence to proceed specification by specification, and such an approach is permissible, with the agreement of the WAC Chairman. Concurrence by the repository project will mean that the producer's proposed method of compliance will satisfactorily meet the intent of the specification, acceptance criteria (as applicable), and support requirements for licensing.

The WQR is a compilation of all results from testing and analysis that presents detailed evidence of compliance with each specification. This document is also prepared by the producer and concurred with by the repository project. Concurrence by the repository project will be required for each specification and will mean that results from the testing and analysis as described and documented provide a satisfactory demonstration of compliance with the specification and are adequate for the intended use in repository licensing. Again to meet schedule demands, it may be necessary for WQR preparation and concurrence to proceed specification by specification, and such an approach is permissible, with the agreement of the WAC chairman.

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

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

in accordance with the Waste Acceptance Process, through the WAC.

1. WASTE FORM SPECIFICATIONS

1.1 CHEMICAL SPECIFICATION

The waste form for DWPF is borosilicate waste glass.

1.1.1 Chemical Composition Projections

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

1.1.2 Chemical Composition During Production

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

1.2 RADIONUCLIDE INVENTORY SPECIFICATION

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

1.2.1 Radionuclide Inventory Projections

The producer shall provide in the WQR estimates of the total quantities of individual radionuclides to be shipped to the repository and of the uncertainties in the expected values. The producer shall also provide in the WQR estimates of the inventories of individual radionuclides expected to be present in each canistered waste form produced at the facility and the expected range of variations due to process variations during the life of the facility. These estimates shall be calculated for the year 2025. The

method used to make these projections shall be described by the producer in the WCP.

1.2.2 Radionuclide Inventory During Production

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

1.3 SPECIFICATION FOR RADIONUCLIDE RELEASE PROPERTIES

The producer shall control the radionuclide release properties of the waste form during waste form production to satisfy the requirements of Specifications 1.3.1 and 1.3.2, or Specification 1.3.3. The producer shall describe the intended method for demonstrating compliance in the WCP. Supporting technical documentation for the selected method of control shall be included in the WQR. Documentation supporting the selected method of verification of compliance and the verification of results shall be included in the production records.

1.3.1 Control of Radionuclide Release Properties

For the Nevada Nuclear Waste Storage Investigations Project, the capability of the waste form to limit releases of radionuclides shall be demonstrated using test MCC-1 (Materials Characterization Center-1, Nuclear Waste Materials Handbook, DOE/TIC-11400, 1983) conducted in deionized water at 90°C. The test duration is to be 28 days. The acceptance criterion is that the normalized elemental leach rate for the matrix elements sodium, silicon, and boron, and for the radionuclides cesium-137 and uranium-238 shall be less than one gram per square meter per day averaged over the 28 day test duration.

1.3.2 Verification of Radionuclide Release Properties

The capability of the waste form to meet this specification shall be demonstrated by testing actual production samples of waste forms. The sampling schedule shall be sufficient to demonstrate at the 95 percent confidence level that 95 percent of the production waste forms would yield leach test results that conform to the criterion. Test samples shall be taken from a convenient location near the mouth of the waste form canister before the canister is sealed closed. The temperature of the waste form at the time of sampling shall be no higher than 90°C.

1.3.3 Alternative Means of Compliance

The producer may use an alternative approach to demonstrate control of the radionuclide release properties of the waste form from that of Specifications 1.3.1 and 1.3.2 provided that the producer relates, to the satisfaction of the repository project, the radionuclide release properties of the waste form obtained using the alternative approach to those that would be obtained by adhering to the requirements of Specifications 1.3.1 and 1.3.2.

1.4 SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

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

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

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

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

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

2. CANISTER SPECIFICATIONS

2.1 MATERIAL SPECIFICATION

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

2.2 FABRICATION AND CLOSURE SPECIFICATION

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

2.3 IDENTIFICATION AND LABELING SPECIFICATIONS

2.3.1 Identification

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

2.3.2 Labeling

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

of attachment in the WCP. The producer shall estimate the service life of the label and provide a basis for meeting that estimate in the WCP.

3. CANISTERED WASTE FORM SPECIFICATIONS

3.1 FREE-LIQUID SPECIFICATION

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

3.2 GAS SPECIFICATION

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

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

3.3 SPECIFICATION FOR EXPLOSIVENESS, PYROPHORICITY, AND COMBUSTIBILITY

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

3.4 ORGANIC MATERIALS SPECIFICATION

After closure the canistered waste form shall not contain organic

materials. The producer shall describe the method for complying with this specification in the WCP and document the detection limit for organic materials in the WQR.

3.5 FREE-VOLUME SPECIFICATION

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

3.6 SPECIFICATION FOR REMOVABLE RADIOACTIVE CONTAMINATION ON EXTERNAL SURFACES

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

Alpha radiation: 220 dpm/100 cm^2

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

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

3.7 HEAT GENERATION SPECIFICATION

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

3.7.1 Heat Generation Projections

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

3.7.2 Heat Generation During Production

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

3.8 SPECIFICATION FOR MAXIMUM DOSE RATES

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

3.8.1 Projections of Dose Rates

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

3.8.2 Dose Rates at Time of Shipment

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

3.9 CHEMICAL COMPATIBILITY SPECIFICATION

The contents of the canistered waste form shall not lead to internal corrosion of the canister such that there will be an adverse effect on normal handling during storage, transportation, and repository operation. The producer shall describe the method of compliance in the WCP and document in the WQR the extent of corrosiveness and chemical reactivity among the waste form, the canister, and any filler materials. Corrosion, chemical interactions, and any reaction products generated within the canistered waste forms after exposure to temperatures up to the transition temperature of Specification 1.4(a) shall be evaluated in the WQR.

3.10 SUBCRITICALITY SPECIFICATION

The producer shall ensure that the canistered waste form will remain subcritical under all credible conditions likely to be encountered from production through receipt at the repository. The calculated effective neutron multiplication factor, k_{eff}, shall be

sufficiently below unity to show at least a 5 percent margin after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation. The producer shall describe the method of compliance in the WCP and provide supporting documentation in the WQR. The WQR shall also include sufficient information on the nuclear characteristics of the canistered waste form to enable the repository project to confirm subcriticality under repository storage and disposal conditions.

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

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

3.11.1 Weight Specification

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

3.11.2 Length Specification

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

3.11.3 Diameter Specification

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

3.11.4 Specification for Overall Dimensions

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

3.12 DROP TEST SPECIFICATION

The canistered waste form at time of shipment shall be capable of withstanding a drop of 7 m onto a flat, essentially unyielding surface without breaching. The producer shall describe the method of compliance in the WCP and present the supporting documentation of analysis and test results in the WQR. The test results shall include information on measured canister leak rates and canister deformation after the drop test.

3.13 HANDLING FEATURES SPECIFICATION

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

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

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

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

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

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

4. QUALITY ASSURANCE SPECIFICATION

The producer shall establish, maintain, and execute a quality as-

surance (QA) program that complies with OGR/B-14, Quality Assurance Requirements for High-Level Waste Form Production. The quality assurance program shall be applied to all testing and analysis activities that provide information to be included in WQRs. The WCPs shall be prepared in accordance with the QA program; however, existing data generated prior to the inception of the subject QA program may be included in the WCP so long as the specific QA measures that were in effect when the data were generated are described. The quality assurance program shall also be applied to all activities that affect compliance with waste acceptance specifications during waste form production, handling, storage, preparation for shipment, and shipment to the repository. The producer shall describe his QA program in the WCP and certify compliance with it in the WQR, and in production records.

GLOSSARY FOR WASTE ACCEPTANCE PRELIMINARY SPECIFICATION

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

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

Canister breach - loss of canister leaktightness.

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

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

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

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

Free-gas - any gas, including radiogenic gases and cover gases like helium, argon, or air, that could contribute to the pressurization of the canister at temperatures below the glass transition

temperature. This includes gases mechanically trapped in the waste form and those generated by chemical reaction and radiolytic decomposition.

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

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

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

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

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

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

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

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

Radiogenic gas - any gas produced by radioactive transformation; that is, the transmutation of an element into a gaseous element by

a change in the atomic nucleus through processes such as fission, fusion, neutron capture, or radioactive decay.

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

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

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

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

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

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

RATIONALE FOR WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

1. WASTE FORM SPECIFICATIONS

1.1 RATIONALE FOR THE CHEMICAL SPECIFICATION

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

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

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

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

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

1.2 RATIONALE FOR THE RADIONUCLIDE INVENTORY SPECIFICATION

The total radionuclide inventory is required for a determination of the producer's contribution to the repository source term for calculations to show compliance with 40 CFR 191 total release standards. A year was needed for indexing radionuclide inventory values. The year 2025 was chosen to serve this purpose. Inventory estimates for each canistered waste form are required to confirm that each canistered waste form falls within ranges considered in licensing, safety, and isolation assessments, and for estimates of releases under unanticipated processes and events, and accident scenario conditions. Expected variations in radionuclide inventories are necessary to adequately quantify uncertainties in radionuclide release estimates for repository performance assessments. The minimum concentration of 0.05 percent is needed to ensure that all isotopes of possible consequence to safety and isolation analyses are included, assuming that congruent dissolution of all radionuclides occurs upon contact with an aqueous environment. It provides a factor of 2 reduction with respect to the 0.1 percent limit on isotopes which must be considered in

meeting the 10 CFR 60.113 release rate criterion; it also provides a reasonable lower bound for assessment of releases during accidents. The half-life criterion needs to be as low as 10 years so that "pre-closure" exposure and accident concerns can be addressed.

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

1.3 RATIONALE FOR THE SPECIFICATION FOR RADIONUCLIDE RELEASE PROPERTIES

The justification for this specification is the need for control of waste form release properties during production and the need for information concerning the release of radionuclides from the waste form that is based on or can be related to repository-site-specific release tests and sampling criteria. The repository-site-specific test procedures and the correlation of the data obtained using these test procedures with waste form release properties under repository conditions were developed to satisfy regulatory criteria. Both the Nuclear Regulatory Commission criteria (10 CFR 60) and the Environmental Protection Agency criteria (40 CFR 191) have defined long-term radionuclide release in terms of the engineered barrier system and the mined geologic disposal system respectively. As a component part of these systems, the waste formmay be required to contribute to the compliance with these requirements. The preliminary allocation of performance requirements among the various components of the engineered barrier system and the repository system is to be described in repository Site Characterization Plans. Therefore, site-specific tests and sampling specifications are required.

Specification 1.3.3 provides the producer with the flexibility to employ an approach to demonstrate control of the radionuclide release properties of the waste form that is different from that of Specifications 1.3.1 and 1.3.2 in recognition that another approach may better lend itself to the producer's waste form production process. The producer must demonstrate the relationship between the results obtained from any alternative approach and those which would be obtained by adhering to the requirements of Specifications 1.3.1 and 1.3.2 to provide assurance that the radionuclide release specification will be met.

1.4 RATIONALE FOR THE SPECIFICATION FOR CHEMICAL AND PHASE STABILITY

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

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

- Neither energy input nor radioactive decay significantly affect radionuclide release from waste glass, as long as the temperature of the glass does not exceed the glass transition temperature (approximately 500°C). Above this temperature, significant changes in phase composition can occur.

- For glasses of the type that will be produced by DWPF, even changes in phase composition due to devitrification do not greatly alter the rate of release of material from the glass.

A program has been and continues to be in place to ensure that the effects of energy input and radioactive decay on glass properties are well-understood.

The requirement for certification of conditions during transportation has been included herein to identify the need for consideration of these requirements during design of the transportation system. Certification of conditions during transportation will be the responsibility of the transporter, not the producer.

2. <u>CANISTER SPECIFICATIONS</u>

2.1 RATIONALE FOR THE MATERIAL SPECIFICATION

The repository must have a complete materials inventory to evaluate long term performance under repository conditions. Austenitic stainless steel has been selected as the canister material for DWPF. This specification acknowledges that fact and establishes the repository's interest in this interface. The current role of the canister as part of the engineered barrier system does not require the canister to act as a post-closure engineered barrier; therefore, the primary requirement of the canister material speci-

fication is to ensure that the canister material does not have an adverse impact on waste package performance. By specifying austenitic stainless steel which is manufactured to the ASTM specification. this requirement is met. Additionally, identification of the materials is necessary to assure that the canister material, and the material of any other component present in significant quantities (i.e., secondary canisters and welding fillers), are compatible with other materials in the repository.

2.2 RATIONALE FOR THE FABRICATION AND CLOSURE SPECIFICATION

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

2.3 RATIONALE FOR THE IDENTIFICATION AND LABELING SPECIFICATIONS

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

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

3. <u>CANISTERED WASTE FORM SPECIFICATIONS</u>

3.1 RATIONALE FOR THE FREE-LIQUID SPECIFICATION

The regulatory requirements outlined in 10 CFR 60.135(b)(2) state that, "The waste package shall not contain free-liquids in an amount that could compromise the ability of the waste package to

achieve the performance objectives relating to containment of HLW (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of waste package perforation during the period through permanent closure."

3.2 RATIONALE FOR THE GAS SPECIFICATION

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

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

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

In general, an internal pressure P in a cylindrical vessel of diameter D and wall thickness t produces a tensile hoop stress of

$$\sigma_H = PD/2t$$

and a tensile longitudinal stress of

$$\sigma_L = PD/4t$$

in the wall of the vessel (Popov, 1959). For a vessel made from

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

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

Type 304L stainless steel, the yield strength at 500°C would be at least 14,000 psi (ASM, 1980). The more rapid cooling of the canister wall than the bulk of the glass after pouring as well as differences in the coefficients of thermal expansion of the two materials are expected to lead to tensile thermal stresses approaching or exceeding the yield strength of the stainless steel (Baxter, 1983). In order for the stresses due to internal pressurization to be insignificant in comparison, it would be sufficient to limit them to a small percentage of the yield strength. lf the hoop stress is limited to 10 percent of the yield strength at 500°C or 1400 psi, the maximum internal pressure would be 44 Psi at 500°C, which is equivalent to 17 psi at 25°C.

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

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

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

The regulatory requirements as outlined in 10 CFR 60.135(b)(1) state that, "The waste package shall not contain explosive or pyrophoric materials in an amount that could compromise the ability of the underground facility to contribute to waste isolation or the ability of the geologic repository to satisfy the performance objectives."

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

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

3.4 RATIONALE FOR THE ORGANIC MATERIALS SPECIFICATION

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

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

3.5 RATIONALE FOR THE FREE-VOLUME SPECIFICATION

In general, free-volume is to be minimized for the following reasons: 1) repository design; 2) economical use of repository space; and 3) less volume of water in contact with waste form in the event of breach of containment followed by infiltration of ground water.

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

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

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

3.7 RATIONALE FOR THE HEAT GENERATION SPECIFICATION

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

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

An accuracy of ± 15 percent is judged to be a reasonable working value, acceptable to both the repository project and to the producer. Information on the range of expected variation in heat generation rates is necessary to allow assessment of uncertainties in repository performance.

3.8 RATIONALE FOR THE SPECIFICATION FOR MAXIMUM DOSE RATES

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

3.9 RATIONALE FOR THE CHEMICAL COMPATIBILITY SPECIFICATION

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

3.10 RATIONALE FOR THE SUBCRITICALITY SPECIFICATION

The regulatory requirements as outlined in 10 CFR 60.131(b)(7) state that, "The calculated effective multiplication factor k_{eff} must be sufficiently below unity, to show at least a 5 percent margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to evaluate the method of calculation."

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

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

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

3.12 RATIONALE FOR THE DROP TEST SPECIFICATION

This specification is intended to demonstrate that the canistered waste form can withstand severe physical impact without breaching. By requiring that the canistered waste form pass a performance (drop) test without breaching, this specification obviates the need for the alternative approach of establishing detailed specifications on the material properties of the canister and the waste form necessary to describe the radionuclide source term associated with the possible breach of a canister as a result of a drop accident. The drop height of 7 m was chosen as representative of the maximum drop height under normal operating conditions. The surface which is characteristic of normal operating conditions has been defined as a "flat, essentially unyielding" surface.

3.13 RATIONALE FOR THE HANDLING FEATURES SPECIFICATION

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

4.0 RATIONALE FOR THE QUALITY ASSURANCE SPECIFICATION

All activities relevant to licensing of a repository must be conducted in accordance with appropriate quality assurance controls. The Office of Civilian Radioactive Waste Management's quality assurance policies and requirements applicable to the high-level waste form production are described in the referenced document. High-level waste form production activities must be conducted in compliance with the quality assurance policies and requirements established by the Office of Civilian Radioactive Waste Management.

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 Civilian Radioactive Waste Management has defined the minimum specifications the DWPF product must meet to be acceptable for disposal at an underground repository. These Waste Acceptance Preliminary 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 repository, 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.

CONTENT

The Production Records will be summaries of the detailed records of canistered waste form production in the DWPF. These detailed records will be collected and maintained as a computerized database, by the DWPF. The Production Records will provide references to these detailed records for retrievability purposes, where necessary. It is the intent of the DWPF to provide the detailed records of canistered waste form production at time of shipment of the canistered waste forms. However, the amount of information contained in those detailed records will be so large that meaningful use of them will be impossible without a summary which points out the information of importance to the Waste Acceptance Process. The content of the Production Records is presented below. The information to be reported is summarized in Table 1.200.1.1. Any actions to be taken based on the information are also identified.

According to the Mission Plan for the repository program, DWPF canistered waste forms will not be accepted at a civilian repository until at least 2003. Thus, DWPF has not yet designed a shipping facility for canistered waste forms. Such a facility will undoubtedly contain smear test stations, equipment to measure the weight and dimensions of canistered waste forms, and other equipment necessary to satisfy whatever specifications are in existence at that time. However, this Appendix ignores the shipping facility, and only considers equipment, instrumentation, and information which is available within the current scope of the DWPF.

Macrobatches

A key concept for both the chemical composition and the radionu-

clide inventory is the "macrobatch." The feed to the DWPF from processing of soluble salts is expected to change only three times a year, and then only very slowly because of "heels" in the waste tanks. The insoluble sludge batches will change even less frequently (every two to three years). Thus, the feed to the DWPF will remain fairly constant for periods of three to four months at a time. These periods of constant feed constitute macro-batches.

Identification and Labelling

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 Production Records will be provided by the DWPF (Production) to the repository operator, prior to shipment of canisters. This will not occur for at least fifteen years after production. This implies that the Production Records, and the detailed records of canistered waste form production, will have to be maintained in a retrievable fashion for a substantial period of time. Thus, the Production Records will be generated as soon as possible after production of the canistered waste form is completed, and then held as lifetime quality records.

Use of Glass Samples

Samples of production glass will occasionally be taken from the Melt Cell (see Part 3, Items 200, 400, 500 and 550), and sent to SRL to verify radionuclide release properties using the Product Consistency Test, and for chemical and radiochemical analyses. These results will be included in the Production Records as Addenda, and will be used to improve the correlation between feed composition and glass composition. They will also provide evidence that the radionuclide release properties of the glass have been controlled. These will be treated as lifetime quality records.

Chemical Composition During Production

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. This information will be calculated from

analyses of samples from the Melter Feed Tank.

The values to be reported in the Production Records will be the numerical average and standard deviation calculated from the individual elemental analyses for an entire macrobatch, expressed as oxides in the glass. Thus, the reported chemical composition will be the same for all canisters produced from a given macro-batch of feed.

This composition will have to be within the range of compositions projected for the DWPF (see Part 3, Item 100). If the composition is outside the projected range, then the batch of glass-filled canisters will have to be identified as nonconforming items, and then dispositioned according to the procedure outlined in Part 6, Item 800, of the Waste Form Compliance Plan.

Radionuclide Inventory During Production

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 at any point up to 1100 years after production. This information will be calculated from radiochemical analyses of samples from the Melter Feed Tank.

The values to be reported in the Production Records will depend on the particular radionuclide. However, for all radionuclides the reported inventory will be the same for an entire macrobatch, and will be expressed as curies per unit mass of glass. The values to be reported will be determined in one of two ways.

- The inventory of radionuclides which are analyzed for in the DWPF will be reported as the numerical average and standard deviation calculated for an entire macro-batch.

- The inventory of radionuclides which cannot be analyzed for in the DWPF will be reported as a proportion of the value for one of the analyzed species. In this case, only an average value will be reported.

There are no 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 a sort of limit on the allowed radionuclide inventory.

Control and Verification of Radionuclide Release Properties

The proposed strategy for compliance is to report that the chemical composition of the glass produced is within the range of projected compositions (as noted above), and to provide evidence that any other property which affects the ability of the glass to retain radionuclides was controlled. At the present time, composition is the only property which has been shown to have an effect. The results of testing of glass samples will be reported as Addenda to the Production Records.

Chemical and Phase Stability

The WAPS require that the DWPF certify that, after cooling from filling, the canistered waste form has not been exposed to temperatures greater than its glass transition temperature (~450°C). After filling, the canister will be held in the Melt Cell until it cools below 100°C. After the canister is transferred to the Canister Decontamination Cell, it can exceed the specified temperature (~450°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 Building (GWSB) and the projected heat generation rates will be used to show that the specified temperature (~450°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 GWSB, has exposed the glass to high temperatures. The temperature control on the forced air cooling system in the GWSB will provide the data upon which certification is to be based. This data will be taken for the entire period for which the canistered waste forms are stored.

In either case, if the glass temperature may have exceeded the high temperature limit, then the batch of glass-filled canisters will be identified as nonconforming items, and dispositioned according to the procedure outlined in Part 6, Item 800, of the

Waste Form Compliance Plan.

Canister Material

The WAPS require that the DWPF certify that the canister materials were the same as those specified in the Waste Form Compliance Plan. 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, and inspection records. Records of inspections performed at Savannah River, for example to verify that alloy composition meets specifications, will also be cited in the Production Records. Nonconforming canisters will not be accepted for DWPF use.

Fabrication and Closure

The WAPS require that the DWPF certify that the canisters produced in the DWPF are leaktight. Certification of the canister's integrity will be based upon:

- Fabrication of the canister itself according to specifications. Records of inspection and testing to verify that canister fabrication was according to specifications will be cited in the Production Records. Nonconforming canisters will not be accepted for DWPF use.

- Process control of the final closure weld in the DWPF. The Production Records will report the force, current, and duration of application of the current and force as recorded by the data acquisition system for 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, and then dispositioned according to the procedure outlined in Part 6, Item 800, of the Waste Form Compliance Plan.

Canister Content Controls

The WAPS require that the DWPF certify that the canister contains no free liquids, no free gases (other than those present in the Vitrification Building), no explosives, pyrophorics or combustibles, and no organic materials at time of shipment. This certification will be based upon:

- The ability of the temporary seal emplaced immediately after

filling to prevent materials, particularly liquids, from entering the canister. The Production Records will contain the results of leak testing the temporary seal.

• The ability of the canister closure weld and fabrication welds to prevent these materials from entering the canister. The certification of the canister fabrication and closure welds described above will be used to satisfy this requirement.

• Any active control procedures taken to prevent these materials from entering the canister. The Production Records will cite these by their unique identification number, including the version actually used. As this implies, any such procedures will be lifetime quality records.

Free Volume

The WAPS require that the DWPF report, in the Production Records, the free volume within each canister. This information will be obtained from both the neutron and gamma level detectors. The reported values should be within 3 % of the actual value. The Production Records will report both values. The canister weight and visual determination of the glass fill level (external "bluing") may be reported as confirmatory information.

Although there is a nominal limit on the free volume of 20% of the total internal volume, the WAPS recognize that this will periodically be exceeded. The Production Records for each canister which has greater than 20% free volume should clearly indicate this, but no action is necessary if this value is exceeded.

Removal of Canister Contamination

The WAPS require that the DWPF report, in the Production Records, the smear test results for each canister. If the level of contamination exceeds 220 alpha dpm/100 cm^2, or 2200 beta or gamma dpm/100 cm^2, the canister will be decontaminated again, before it leaves the vitrification building. In this case, the results of a confirmatory smear test will also be reported.

The DWPF will also inspect the canister to ensure that there is no visible glass adhering to the outer surface. The inspector will be identified by name and badge number. If there is visible glass on the outside of the canister, the procedures used to remove this

glass will be identified, as well as the individuals performing them. The results of a confirmatory smear test will be reported for this case, as well.

Heat Generation Rate

The WAPS require that the DWPF report, in the Production Records, the heat generation rate for the canistered waste forms. The heat generation rate will be calculated from the radionuclide content of the glass, using standard values 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, and all radionuclides analyzed for process control purposes in the DWPF.

If the heat generation rate exceeds 800 watts at time of shipment of the canister from the DWPF, then the canister will be identified as a nonconforming item, and then dispositioned according to the procedure outlined in Part 6, Item 800, of the Waste Form Compliance Plan.

The WAPS also require that the DWPF certify, in the Production Records, that the reported heat generation rate for the canistered waste forms be accurate within 15%. SRL intends to address this generically in the Waste Form Qualification Report so that it will not need to be routinely addressed in the Production Records. If the scheme outlined above is followed, then the heat generation rates should have the required accuracy.

Gamma and Neutron Dose Rates

The WAPS require that the DWPF report, in the Production Records, the gamma and neutron dose rates for the canistered waste forms, at time of shipment. During production, these will be measured just before the canistered waste form is transferred from the vitrification building to the interim storage building. At time of shipment, these will be measured again in the DWPF shipping facility.

If the calculated dose rates exceed 10^5 rem/hr surface gamma dose rate, or 10^3 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 800, of the Waste Form Com-

pliance Plan.

Weight, Length, Diameter, and Overall Dimensions

The WAPS require that the DWPF report the weight, length, diameter, and bow of each glass-filled canister in the Production Records. The weight will be obtained from load cells in the Melter Cell, and confirmed by weighing in the shipping facility. The diameter and length will be reported based on measurements of the canistered waste form prior to shipment from the DWPF. The bow of the glass-filled canisters will either be measured directly, or will be certified based on the ability of the canister to fit, without forcing, into the shipping cask or a template of the cask.

The WAPS also require that the DWPF certify, in the Production Records, that the reported weight of canistered waste forms be accurate within 5%. Thus, the load cells used to determine the canistered waste form's weight will be calibrated, and certified accurate within 5%. The WAPS do not require that evidence of their calibration be reported, but this evidence will be contained in the detailed records of canistered waste form production.

TABLE 1.200.1.1 Content of DWPF Production Records

Specification	Information in the Production Records
1.1.2	Elemental composition of glass (For all elements > 0.5 wt% of glass)
1.2.2	Estimates of radionuclide inventory (For all radionuclides with $\tau_{1/2}$ > 10 yr and > 0.05 % of Ci for times between 0 and 1100 years)
1.3	Certification that elemental composition is within envelope projected in WCP; and results of chemical analyses and performance of Product Consistency Test on glass samples
1.4	Certification that waste form kept below ~ 350°C
2.1	Canister procurement documents
2.2	Evidence fabrication welds made as specified
2.2, 2.3	Drawings and procedures
2.2	Closure weld parameters
2.3	Identification of canisters
3.1, 3.9	Leak test result on temporary canister closure
3.1	Certification that liquids controlled
3.2	Certification that controls used to keep out gases
3.3	Certification that controls used to keep out explosives, pyrophorics, and combustibles
3.4	Certification organics controlled
3.5	Free volume
3.6	Smear test results
3.6	Certification no visible glass on canister exterior
3.7.2	Heat generation rate (± 15 %)

Specification	Information in the Production Records
3.8.2	γ, n dose rates at time of shipment
3.11	Weight of filled canister (± 5 %)
3.11	Diameter, length
3.11	Certify that canister fits without forcing into cask

SUMMARY

DWPF INTEGRATED COLD RUN ACTIVITIES

RELEVANT TO WASTE ACCEPTANCE PROCESS

APPENDIX 1.200.2 Summary of DWPF Integrated Cold Run Activities Relevant to the Waste Acceptance Process

OBJECTIVES

The objectives of the DWPF Integrated Cold Run 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 Preliminary Specifications (WAPS).

TESTS TO DEMONSTRATE COMPLIANCE WITH WASTE ACCEPTANCE PRELIMINARY SPECIFICATIONS

The sections below describe specific tests which will be performed during the Integrated Cold Run for inclusion in the Waste Form Qualification Report. 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. At the present time, there is no intent to report on these activities, so they will not be discussed further here.

Chemical Composition During Production (Specification 1.1.2)

The objective of this test is to confirm the mathematical relationship used to predict the glass product composition from the melter feed composition. In order to achieve this objective, the DWPF will have to demonstrate that it can reliably sample and analyze melter feed materials. As part of this demonstration, the precision and accuracy of the methods which will be used to determine glass composition will be established. This will be accomplished by determining the composition of samples of glass from each canister filled, and by analyzing the melter feed on the same frequency as will be used in the DWPF.

The initial charge to the melter will be a glass frit specially-formulated for melter startup. After building the melter level to the operating level using sludge-only feed, a series of test runs will be made to analyze the melter behavior. These test runs will be sludge/precipitate runs with (in order of performance)

a) composite feed to purge the startup (black) frit from the melter and establish a base condition,

b) a nonradioactive doped composition to simulate variations around the composite feed,

c) a high viscosity (high aluminum) composition to simulate an extreme change in feed composition,

d) a low viscosity (high iron) composition to simulate another extreme change in feed composition, and

e) composite feed to simulate return to standard operation from low viscosity (In addition, two other runs, one with mercury and one with a radioactive dopant will be performed to demonstrate equipment operability).

At least one of these runs will require addition of supplemental chemicals to demonstrate that the feed composition can be adjusted, if required. Approximately 90,000 pounds of glass will be made during each of these tests to provide about a 98% changeover of melter composition, assuming that the melter behaves like a well-stirred tank.

Control of Radionuclide Release (Specification 1.3.1)

Since chemical composition is the most important determinant of glass durability, analysis and testing (using the DWPF Product Consistency Test - PCT) of glass samples from canisters produced will be used to demonstrate the correlation between feed composition and glass properties. The canisters produced during the Integrated Cold Run) will also be sectioned, and the behavior of grab samples compared to samples of glass taken from the canisters.

Verification of Radionuclide Release Control (Specification 1.3.2)

This verification results from the periodic sampling of the Melter Feed Tank and the product during radioactive operation. During the DWPF Integrated Cold Run, samples will be taken remotely, transported for analysis, analyzed and tested (using the PCT) to verify control of radionuclide release.

Chemical and Phase Stability (Specification 1.4)

Cooldown profiles for the canisters obtained during pilot-scale testing will be verified under typical production conditions to satisfy this specification. In addition, the effect of placing a canister in the Melt Cell Insulated Storage Rack on the thermal profile will be evaluated. Special instrumented canisters will be designed and procured to perform these tests.

Fabrication and Closure (Specification 2.2)

Confirmation of the parametric weld study using the DWPF welder will be performed. Initial runs will be made on dummy heads, and will span the entire operating range. Then full-scale canisters will be used to demonstrate actual operation. The repair cap weld procedure will also be demonstrated. The quality of the welds produced will be verified by metallurgical characterization, and physical testing.

Free Liquids (Specification 3.1)

Tests will be performed to confirm that the Inner Canister Closure, when installed under typical operating conditions, prevents intrusion of water, particularly from the canister decontamination operation. This test may require canister modifications to physically examine the void volume of the canister for moisture.

Free Volume (Specification 3.5)

Confirmation of an operable level detection system is required to demonstrate control of the free volume in the canister (desired minimum fill is 80%). DWPF has four systems: weigh cells, neutron penetration, gamma radiation and visual viewing of canister blueing. Gamma radiation detection will not be available during the Integrated Cold Run. Evaluation of the other three methods of level detection will be made during the DWPF Integrated Cold Run.

DWPF PRODUCT CONSISTENCY TEST

APPENDIX 3.500.1 DWPF Product Consistency Test

TEST DEVELOPMENT AND STATUS

An extraction test, designated the Product Consistency Test (PCT), has been developed for DWPF glass in order to meet the requirements of the Waste Acceptance Preliminary Specifications (WAPS). The development program will be documented in the Waste Form Qualification Report, and so is only summarized here.

Several of the Waste Acceptance Preliminary Specifications (WAPS) require testing of glass samples to demonstrate the control of radionuclide release. For example, Specification 1.3 (see Part 3, Item 500) requires that the DWPF demonstrate control of the radionuclide release properties of the canistered waste form during production. WAPS Specification 1.4 requires that the release properties of devitrified glass samples be determined in the same manner.

The repository project is responsible for developing the site-specific radionuclide release tests which would be used to meet these requirements. The repository project has selected the Materials Characterization Center's MCC-1 test as the basis for acceptance. However, there are several factors which make development of a simple, reliable test of product consistency very desirable for the DWPF.

- The MCC-1 test is not very sensitive to glass consistency, because it has a low surface area-to-volume of leachant (SA/V) ratio. Thus, it is not as likely to be a useful indicator of production control (in the sense of WAPS 1.3) as a test with a much higher SA/V ratio.

- The MCC-1 test requires the use of rectangular monolithic samples. However, glass samples taken during production will not be annealed, and so have a high likelihood of breaking during cutting into rectangular prisms.

- The MCC-1 test was only formally established by the repository project in June, 1988. Unless a shorter-duration test was developed quickly for DWPF, the results needed to prepare the Waste Form Qualification Report would not be available in time for adequate review.

Thus, the main objectives of the test development program were to provide a means to demonstrate the consistency of DWPF glass during production, and to develop a reliable test which could be used to provide the large body of data required by the WAPS. During

development of the test, the following were considered:

- Sensitivity of the test to glass composition and homogeneity,
- Time necessary to determine product consistency,
- Ease of sample preparation for radioactive glass,
- Ease of performance with production glass samples, and
- Precision of the test results.

Several types of tests were considered. The MCC-3 Agitated Powder Leach Test[1] from the Materials Characterization Center was selected as the basis for further development for the following reasons:

- The MCC-3 is a widely-used test protocol, with well-known characteristics. Thus, modification could begin from a well-defined starting point.

- The test temperature (90°C) and the test leachant (deionized water) are readily attained.

- Crushing of highly radioactive glass is a much easier operation to perform reliably than the cutting required by MCC-1. Crushing is not likely to be adversely affected by the lack of annealing of production samples. Use of grains from crushing would lead to a test with higher SA/V ratio, i.e. the test would be more sensitive to the glass than the MCC-1 test.

- At a fixed short time (e.g. 7 days), concentrations of species in solution in crushed glass leach tests are higher than in monolithic tests. Thus, the analyses of the leachates are likely to be more precise.

A draft test protocol (Version 1.0) was then drawn up, and used by three researchers in SRL in a round-robin test, using a wide range of glass compositions. The following conclusions were derived from this study:

- The PCT test was found to be sensitive to glass composition and to glass homogeneity. Thus, it should be a good indicator of glass product consistency.

- A 7-day test duration was found to give reproducible results. Shorter test durations could be used but the leachate results were less precise.

- Sample preparation and the test procedure could be made simple enough for reliable remote operation without compromising the PCT response to glass composition and glass homogeneity and without loss of precision.

- Vessel cleaning could be simplified (compared to MCC-3) for remote operation and more rapid sample evaluation.

- Variations among the three investigators were within ~ 15% for homogeneous glass samples.

Based on the results of this study, a revised test protocol (Version 2.0) was prepared. This test protocol has now undergone independent review, and will be used in a round-robin test involving several laboratories. The purpose of the round-robin will be to demonstrate that the test will distinguish between acceptable and unacceptable glass, and to determine the precision and accuracy of the test. This version of the test protocol (v. 2.1) has been prepared in response to comments received from the technical reviewers. It does not differ from version 2.0 in any substantive way, but is intended to clarify and improve the presentation of the procedure, so that it can be more reliably performed. Version 3.0 of the protocol will incorporate results from ongoing development efforts, as well as the results from the interlaboratory round robin.

Reference

1. J. E. Mendel (Compiler), **Nuclear Waste Materials Handbook - Waste Form Test Methods**, USDOE Report DOE/TIC-11400, Materials Characterization Center, Battelle Pacific Northwest Laboratories, Richland, WA (1981).

PROTOCOL FOR

PRODUCT CONSISTENCY TEST

FOR DEFENSE WASTE PROCESSING FACILITY (DWPF) GLASS

Version 2.1

PROTOCOL FOR PRODUCT CONSISTENCY TEST FOR DEFENSE WASTE PROCESSING FACILITY (DWPF) GLASS

I. INTRODUCTION

A. Scope

The Product Consistency Test (PCT) is a test method modeled after the MCC-3 Agitated Powder Leach Test which was designed to evaluate the chemical durability of nuclear waste forms. Crushed glass in the 100-200 mesh size range is used in the test. The test is designed to determine whether the radionuclide release properties of DWPF glass have been consistently controlled.

B. Safety

All appropriate precautions for operation of pressurized equipment must be taken. To ensure safe operation, the leach containers should be designed to withstand the vapor pressure of water at the test temperature with an appropriate safety factor. The thermal expansion of water must be taken into account when filling the leach containers. Between filling at 4°C and testing at 100°C water expands by 4 volume percent. Overfilling, e.g. filling a 60 mL vessel to 55 mL, may lead to pressures inside the container that exceed the design limits, and could lead to the failure of one or more parts of the vessel.

II. APPARATUS, EQUIPMENT, AND ANALYTICAL REQUIREMENTS

A. Leach Containers

1. New Teflon® Containers

The procedure below is specifically for PFA Teflon®. The volume of the leach container for routine tests will be approximately 60 mL. The vessels should be designed to take internal pressures of at least 75 psi without leaking. For the cleaning procedure and reuse of Teflon® vessels, see Section II.A.3.

New Teflon® leach containers shall be cleaned according to the following procedure:

(1) Bake empty vessels in an oven at 200°C for one week.

(2) Soak for 1 hour in 6 M HNO_3 + 0.2 M HF.

(3) Rinse with 3 container volumes of ASTM Type I water (ASTM D-1193).

(4) Soak in 6 M HNO_3 for 4 hours at 50°C.

(5) Soak for 30 minutes in ≥60°C ASTM Type I water.

(6) Soak for at least 8 hours in fresh ASTM Type I water at 80°C.

(7) Boil for 30 minutes in fresh ASTM Type I water.

(8) Rinse with a minimun of 3 container volumes of ASTM Type I water until the pH of two successive rinse solutions is within 0.5 pH unit of the original ASTM Type I water.

(9) Fill the Teflon® containers with 40 mL of fresh ASTM Type I water. Close the lid and leave in a 90°C oven for at least 16 hours.

(10) Measure the pH of an aliquot of the water.

(11) If the pH is not in the range 5.0-7.0, repeat steps 7 through 10.

(12) If the 5.0-7.0 pH range cannot be achieved by 3 repetitions of steps 7 through 10 then repeat the cleaning and testing procedure, starting at Step 4.

(13) Each batch of cleaned cups will be labelled with a unique identifier, and the date when cleaning was completed, for control purposes. In particular, this will facilitate the proper use of blanks.

2. <u>New Steel Containers</u>

a. <u>Leach Vessels</u>

Teflon® vessels cannot be used to leach radioactive glass because the radiation causes degradation of the Teflon®, and formation of HF. This causes increased leaching of the glass due to the pH decrease, and the presence of F^- ions that attack the glass. Steel reaction vessels fabricated of 304L stain-

less steel (e.g. those available from Parr Instrument Co.) shall be used for leaching radioactive glass. For the cleaning procedure to allow reuse of stainless steel vessels, see Section II.A.3.

New steel vessels shall be cleaned by the following procedure:

(1) Clean the vessels and caps (without the gasket) ultrasonically in acetone for ~5 minutes.

(2) Clean the vessels and caps ultrasonically in 95% ethanol for ~5 minutes.

(3) Rinse the vessels and caps three times with ASTM Type I water.

(4) Submerge the vessels and caps in 1% HNO_3 and heat to 90°C for one hour.

(5) Rinse the vessels three times with ASTM Type I water.

(6) Submerge vessels and caps in ASTM Type I water for one hour.

(7) Rinse with ASTM Type I water.

(8) Fill the vessel 80-90% full of fresh ASTM Type I water. Close the lid and leave in a 90°C oven for at least 16 hours.

(9) Measure the pH of an aliquot of the water.

(10) If the pH is not in the range 5.0-7.0, repeat steps 6 through 9.

(11) If the 5.0-7.0 pH range cannot be achieved after 3 repetitions of steps 6 through 9, then repeat the cleaning and testing procedure starting at Step 4.

(12) Each batch of cleaned stainless steel vessels will be labelled with a unique identifier, and the date when cleaning was completed, for control purposes. In particular, this will facilitate the proper use of blanks.

b. Vessel Gaskets

The Parr reaction vessels require a gasket material to remain sealed. Teflon® gaskets, available commercially, are current-

ly being used since Teflon® is chemically inert and the radiation fields experienced thus far are not high enough to damage the gasket. When higher radiation fields are present, it may be necessary to use a special gasket fabricated with ethylene, propylene, or silicone polymer.

New gaskets should be cleaned by the following procedure:

(1) Handle the gaskets with tongs. Rinse each ultrasonically in acetone for ~5 minutes.

(2) Rinse each ultrasonically in 95% ethanol for ~ 5 minutes.

(3) Rinse each under flowing ASTM Type I water for ~ 3 minutes.

(4) Bake each gasket in an oven at 200°C for 4 hours.

(5) Immerse in ASTM Type I water at 90°C for 2 hours.

(6) Allow to air dry and store in a clean glass storage container.

3. Cleaning Procedure for Reuse of Teflon® and Stainless Steel Containers

The procedure below allows for cleaning and reuse of both Teflon® and stainless steel leach containers for nonradioactive glass. The procedure is not as extensive as the initial cleaning procedures outlined in Sections II.A.1 and II.A.2. Currently, reuse of stainless steel vessels for radioactive glass testing is not recommended. However, methods to reliably clean used stainless steel vessels are currently under investigation.

The leach containers shall be cleaned according to the following procedure:

(1) Remove all glass from the vessels and rinse both the vessel and lid with ASTM Type I water.

(2) Submerge vessels in 1% HNO_3 at 90°C for 1 hour. For the Teflon® vessels the lids are also submerged. For the stainless steel vessels the lids and their gaskets are not submerged in the HNO_3 because of the possibility that small amounts of HNO_3 may be trapped between the gasket and the lid.

(3) Rinse vessels and lids thoroughly with ASTM Type I water.

(4) Put vessels and lids (including the steel lids) in ASTM Type I water at 90°C for 1 hour.

(5) Fill the vessel 80-90% full of fresh ASTM Type I water. Close the lid and leave in a 90°C oven for at least 24 hours.

(6) Measure the pH of an aliquot of the water.

(7) If the pH is not in the range 5.0-7.0, repeat steps 4 through 7.

(8) If the 5.0-7.0 pH range cannot be achieved after 3 repetitions of steps 4 through 7, then repeat the cleaning and testing procedure, starting at Step 2.

(9) Each batch of cleaned reused vessels will be labelled with a unique identifier, and the date when cleaning was completed, for control purposes. In particular, this will facilitate the proper use of blanks.

B. Temperature Control

The temperature of the leaching container shall be maintained at the test temperature to ± 2.0°C. Continuous monitoring of the temperature is recommended.

C. Balances

Balances shall provide the sensitivity indicated below, depending on the materials being weighed:

leachant + leach container	within 0.25% of the leachant mass
chemical reagents	within 0.25% of the reagent mass
specimens	within 0.25% of the specimen mass

D. Volume Measurements

Measure leachant volumes gravimetrically or with pipets, burets, flasks, or cylinders accurate to within ± 5%.

E. Specimen Bottle Preparation

Before the scheduled end of the test, boil polyethylene specimen bottles and caps for 1 hour in ASTM Type I water. Allow the specimen bottles and caps to remain in the water overnight but reduce the temperature so that boiling has stopped. Remove the bottles and caps and dry in an oven at 80°C.

F. Solution Analysis

Measure solute concentrations using equipment calibrated with standards traceable to NBS if suitable standards exist. The solution should always be analyzed for Na, B, Si, Li, and K. Determine and report precision and accuracy. Although analytical results should normally be accurate to within ± 10%, this will not be possible when concentrations in the solution approach detection limits. The detection limits for each analysis must accompany the reported result.

G. pH Measurement

Measure the pH to an accuracy of ± 0.2 pH unit using a calibrated meter and commercial buffers.

H. Calibrations and Standards

Calibrate all instruments used in this test initially and periodically to minimize possible errors due to drift (see Table 1).

I. ASTM Type I Water

The Type I water referred to in this procedure will be characterized during the leach test by use of blanks. The Type I water used initially shall meet the following specifications:

Specific Resistance	>16.7 M ohm/cm at 25°C
	<20 M ohm/cm at 25°C
pH	5.5 - 7.0

J. Sample Preparation

Samples of the starting waste-form material may be either fabricated individually or taken from larger samples of the waste-form. The waste-form material shall be pulverized to make test specimens. Document the fabrication method and fab-

rication conditions for the material from which the test specimens are prepared.

If there is concern that the exterior of the sample is not representative, for example, due to interactions with the vessel used in fabrication, then the outer portions of the sample should not be used. In general, this is not a concern, because the use of crushed glass minimizes surface effects.

TABLE 1. Calibration or Standardization of Test Equipment

Measurement	Device	Calibration Frequency and Method
Temperature	Thermocouple or thermometer	6 mo. NBS standards or ice/boiling water
	Electronics of temperature probe without sensor	6 mo. Standard mV source
Mass	Balance	6 mo. NBS standard masses
pH	pH meter	Initially and after every sample with commercial buffer solutions which bracket the leachate pH.
Volume	Volumetric flasks	Use ASTM Class A flasks
	Pipettes or burettes	Use ASTM Class A pipettes or burettes
Particle size	Sieves	Use U. S. Standard ASTM sieves. Change after at most one year. Visually inspect for damage before each use.

1. Crushing

To eliminate contamination from steel particulates use a heavy hammer to break the specimen, wrapped in a clean plastic bag, into a number of small fragments. A mortar and pestle set of

agate, sapphire, or dense alumina may also be used. Pulverize the fragments using a mechanical or manual technique. Acceptable materials for grinding are tungsten carbide, agate, sapphire, or dense alumina. The powder should be sieved to separate out the -100 mesh (149 µm) to +200 mesh (74 µm) fraction by using clean U. S. Standard ASTM brass screens.

2. Handling

If crushed glass must be handled after preparation, clean materials must be used. All powdered specimens must be stored in clean polyethylene, polypropylene or stainless steel containers in a desiccator until they are used or dried at 90°C for 24 hours before use so the powders do not contain adsorbed water when weighed.

K. Quality Assurance

This test method must conform to all applicable quality assurance requirements of the laboratory performing the test.

III. PROCEDURE

All tests should be carried out at least in triplicate according to the procedure given below. This procedure also applies to blanks, except that the specimen powder is omitted.

A "set" of samples shall be considered as those which have been in test in the same oven simultaneously. For each set of samples, two blanks from the same batch of cleaned vessels shall be used. If more than one batch of cleaned vessels is used in a set of samples, then there shall be duplicate blanks from each batch of vessels. The batch cleaning identifier will be recorded for each sample and blank.

The procedure described below applies to ASTM Type I water at 90°C. Samples shall not be agitated.

(1) Determine the pH on an aliquot of the leachant, record the pH and discard the aliquot.

(2) The volume of leachant (V) required is constrained by the volume of the leach container. The reference ratio of leachant volume to sample mass (V_{soln}/m_{solid}) is 10 ± 0.1 mL/g.

For example, a maximum volume of 40 mL and a sample mass of 4g is recommended. Smaller amounts may be used if necessary, but

use of less than 1 g of specimen is not recommended. The (SA/V) of the sample/leachate system shall be examined in the range in which the parameter (SA/V) x (time in days) is ≥ 50 cm^{-1} day (Table 2).

TABLE 2. Experimental Sample Masses, Solution Volumes and Time Durations To Be Used

Sample Wt(g)	Solution Volume(mL)	Time (days)	SA/V** (cm^{-1})	(SA/V)(t) (cm^{-1} day)
4	40	3	19.55	58.65
		5		97.75
		7*		136.85
		14		273.70
		28		547.40

*Required time duration.

**All calculations based on 100-200 mesh size particles and a waste glass density of 2.76 g/cc at ambient temperature. The calculations were made assuming spherical particles whose diameter equalled the average ASTM sieve size opening.

(3) Weigh an empty container and lid. Record the weight.

(4) Place a weighed amount of pulverized specimen in a clean leach container. Reweigh and record the weight.

(5) Add the required volume of leachant (Step 2), and swirl to wet the specimen. Cap the leach container and reweigh. Record total weight.

(6) The testing period starts when the leach container is placed in the preheated oven. Record that date and time (d:h:min). Retighten the lid after 16 hours at temperature, and record whether the lid was ight or required additional tightening.

(7) Before the scheduled end of the test, boil polyethylene specimen bottles and caps for 1 hour in ASTM Type I water, as described in section II. E. Allow the specimen bottles and caps to remain in the water overnight but reduce the temperature so that boiling has stopped. Remove the bottles and caps and dry in an oven at 80°C.

(8) The testing period shall be controlled to within 2%. At the conclusion of the test, record the date and time (d:h:min), and remove the leach container from the oven. Allow the vessel to cool to room temperature in ambient air.

(9) Weigh the leach container plus contents. Record final weight. If the mass loss is calculated to be greater than 10%, stop the test, and repeat the test starting with a new specimen.

(10) Pipette an aliquot of leachate into a clean, disposable, polyethylene beaker for pH determination. Measure and record the pH and discard the aliquot.

(11) For leachate analysis draw a sufficient amount of the remaining leachant through a 0.45µm sterile syringe filter into a sterile disposable syringe. Remove the filter and transfer the contents of the syringe into a clean, preboiled, polyethylene specimen bottle. Remove an aliquot for anion analysis. Do not acidify this aliquot. To the remaining aliquot add an amount of concentrated HNO_3 equal to 1% of the leachate specimen volume, and determine cation concentrations. The filter may be retained for analysis of solids, or discarded.

(12) This step is only required for solids analysis of certain non-radioactive specimens. Record the appearance of the specimen powder, e.g., visible changes in color, agglomeration, and gelatinization. Wash the specimen powder from the leach container with pure water onto a clean 0.45-µm filter or watch glass and air dry or dry at 90°C. A temperature of 90°C will only drive off adsorbed moisture and not water of hydration. After drying, store or analyze. Solids characterization is optional.

IV. CALCULATIONS

A. Use of Blank Data

Correct the leachate concentrations for each time period by subtracting the corresponding blank concentration. The use of the average of the blank data is discussed in IV. B. Blanks are used principally to check if sources of contamination are present.

B. Concentration of Individual Elements in Leachate

Concentration, in units of ppm or mCi/mL will be reported. For each of the triplicate samples the following equation should be used:

$$C_i = \frac{C_{ij}FV_j}{V_j} - \frac{B_iFV_B}{V_j} \qquad (1)$$

where C_i = concentration of element i in the leachate (mg/L);

C_{ij} = concentration of element i observed in the filtered leachate for sample j (mg/L);

FV_j = final volume of leachate in test vessel containing sample j;

B_i = average concentration of element i in replicate blank vessels;

FV_B = average final volume in replicate blanks;

V_j = ideal volume used in the test of sample j.

Alternatively, the concentration of elements in the leachate can be calculated in molarity using the equation:

$$M_i = \frac{m_i}{A_i \cdot V} \qquad (2)$$

where M_i = concentration of element i in leachate (in mol/L);

m_i = mass of element i in the leachate (in g);

A_i = atomic weight of element i (in g/mole);

V = final volume of leachate (in liters).

If the units are mg/L or ppm, the conversion to molarity (M_i) can be simply calculated as follows:

$$M_i = \frac{(C_i (mg/L) \times 10^3)}{A_i} \qquad (3)$$

where C_i is calculated according to equation (1), and A_i is the atomic weight of element i in g/mol.

3. Waste Form Replicates

Initially, three waste form replicates shall be used to provide estimates of experimental variability.

4. Deviations

Report any deviations from the test method, and discuss the expected effect on the results.

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Office of Civilian Radioactive Waste Management

Office of Geologic Repositories
Quality Assurance Requirements for High-Level Waste Form Production
(OGR/B-14)

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February 1988

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U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D.C. 20585

U.S. DEPARTMENT OF ENERGY

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

SPECIFICATION

QUALITY ASSURANCE REQUIREMENTS FOR HIGH-LEVEL WASTE FORM PRODUCTION

August 28, 1987

Approval S. H. Kale Date 1/25/88

S. H. Kale, Associate Director
Office of Geologic Repositories
Office of Civilian Radioactive
Waste Management

FOREWORD

This specification of quality assurance requirements for high-level waste form production was prepared by the DOE Quality Assurance Work Group on Waste Acceptance. This group included representatives or organizations involved in processing of high-level radioactive waste into canistered waste forms for disposal in a licensed Federal Repository. They represent what is being referred to as the waste form producer organizations.

There will be several waste form producer organizations; one associated with each of the high-level waste form production activities of DOE (e.g., Savannah River, West Valley, Hanford, and Idaho). A waste form producer organization is a composite of elements of DOE and their contractors. It is expected that the major participants in a waste form producer organization will be:

DOE Headquarters
DOE Operations Office
DOE Project Office (If separate from an operations office)
Operating Contractors

It is further expected that these major particpants will be associated through organizational, administrative or contractual arrangements such that a vertical tier relationship exist between the individual participants. For example, the waste form producer for Savannah River activities is an organization made up through a vertical relationship which connects downward from the DOE Defense Programs Office (DOE/DP) in Headquarters to the DOE Operations Office at Savannah River (DOE/SR) and through its Defense Waste Processing Facility (DWPF) Project Office to the E.I. DuPont de Nemours and Company (DuPont). DuPont is the operating contractor for waste form production in the DWPF on the Savannah River site. In this arrangement, the DOE Office of Civilian Radioactive Waste Management (OCRWM), also referred to as DOE/RW, is the recipient for the canistered waste forms (products) from the waste form producer. They are responsible for receipt at the waste form production site and transportation to and disposal in the repository.

The specific organizational units of DOE and the operating contractors will vary depending upon which of the waste form producers is involved.

The waste form producer organizations and the DOE/OCRWM are pursuing an integrated strategy for ensuring that canistered waste forms are acceptable for disposal in a licensed Federal Repository. This strategy involves the preparation of an initial specification which outlines the administrative and technical requirements to be met by each canistered waste form. This initial specification is called the Waste Acceptance Preliminary Specification (WAPS). Updated versions of this specification will be issued at key points in the CRWM Program. Hereafter in this specification, it will be referred to as simply the Waste Acceptance Specification (WAS). The second step is the preparation and implementation of a plan that assures that the processes, methods and techniques that

have been developed for waste form production provide canistered waste forms that meet each point of the WAS. This plan is called the Waste Form Compliance Plan (WCP). The third step is the collection of information and data resulting from the execution of the WCP and preparing a composite report which demonstrates that canistered waste forms can meet all aspects of the WAS. This report is called the Waste Form Qualification Report (WQR). Further, the WQR is expected to demonstrate that high-level waste form production can be accomplished with confidence that final canistered waste forms (product) will meet the WAS in all respects. The last step in this process is the collection of information and data resulting from actual production of canistered waste forms and the assembly of a Production Records Package (PR) for each canister of waste which ultimately demonstrates conformance with the WAS. This four-step strategy is referred to as Waste Acceptance Process Activities.

The quality assurance program of a particular waste form producer will ultimately be the composite of the quality assurance programs of each of the major participant organizations. In this arrangement there will be an overall program of the waste form producer made up of constituent programs of each of the major participants in the composite organization. In most cases the major participants may already have quality assurance programs in place, and they may be providing satisfactory results for other DOE projects and programs. To the extent that these programs meet the requirements of this specification and the participant chooses to apply these programs to Waste Acceptance Process Activities, they are expected to be acceptable. In those cases however where no previous program exist or where the participant chooses to not extend its present program to cover Waste Acceptance Process Activities, programs or portions of programs are expected to be developed to implement the provisions of this specification on Waste Acceptance Process Activities of high-level waste form production. As a consequence, the overall quality assurance program of the waste form producer will implement this specification.

Ultimately the quality assurance programs, program descriptions, and program results will be influential in supporting the acceptability of the product to DOE/RW and DOE/RW's ultimate disposal of that product in the licensed Federal Repository. It is expected therefore that these quality assurance programs, program descriptions, and program results related to the waste acceptance process activities will be concurred in by the DOE/RW organization in order to support its repository licensing activities with regard to the canistered waste form.

To facilitate DOE's repository licensing activities the waste form producers will prepare their quality assurance program descriptions in a format and having content that can be used by DOE/RW in its repository license application. Program description documents will be prepared by each waste form producer such that they can be incorporated in the Repository Safety Analysis Report at the proper time. At that time it is expected that these program descriptions will be evaluated by the U.S. Nuclear Regulatory Commission (NRC) against the applicable criteria of the NRC Review Plan for Quality Assurance Programs for High-Level Nuclear Waste Repositories (HLNWR).

To ensure that the program descriptions of waste form producers will be acceptable to the NRC, guidelines on the preparation of such program descriptions have been prepared and placed in the specification as Appendix A. To provide further confidence in their acceptability, a comprehensive evaluation of the program descriptions has been required by the specification. This evaluation

is to be performed against a review plan which has been prepared and placed in the specification as Appendix B. Both Appendix A and Appendix B have been prepared using the current instructions and review plans used by the NRC for the licensing of nuclear facilities. Both of these appendices have been prepared to reflect considerations for high-level waste form production. However, since the program descriptions for high-level waste form production are expected to ultimately be evaluated by the NRC against the review plan for the repository, much of the focus of the instructions and the review plan criteria have purposefully been left in the facility construction and operation-type language that NRC is expected to be using.

The intent is for each waste form producer to prepare and maintain quality assurance program-defining documentation. This documentation doubles as a Quality Assurance Plan for guiding and directing program implementation and as a Program Description which could be used by DOE/RW in satisfying any needs of repository licensing activities with regard to canistered waste forms.

QUALITY ASSURANCE REQUIREMENTS

FOR

HIGH-LEVEL WASTE FORM PRODUCTION

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(Cont'd.)

QUALITY ASSURANCE REQUIREMENTS

FOR

HIGH-LEVEL WASTE FORM PRODUCTION

1.0 GENERAL

This specification identifies the basic requirements for quality assurance programs applied to Waste Acceptance Process Activities of high-level waste form production. It also provides supplementary requirements and guidance on selected activities that have unique importance to Waste Acceptance Process Activities of high-level waste form production. These supplementary requirements are to be applied in conjunction with the requirements embodied or referenced in the basic requirements specified.

2.0 PURPOSE

The purpose of this specification is to define requirements for the quality assurance programs of organizations that are responsible for or involved in high-level waste form production as part of the established waste acceptance process activities.

3.0 SCOPE

The requirements of this specification are for quality assurance activities that are to be performed in Waste Acceptance Process Activities of high-level waste form production. In high-level waste form production, radioactive waste is converted to a waste form and canistered such that the canistered waste form will be acceptable at a Federal Repository licensed by the Nuclear Regulatory Commission (NRC) for disposal of high-level radioactive waste.

The requirements apply to activities of The Department of Energy (DOE) and to operating contractors of DOE facilities who are assigned responsibilities for performing and verifying activities affecting quality in Waste Acceptance Process Activities of high-level waste form production.

The specific organizational units of DOE and the operating contractors will vary depending upon which waste production facility is involved (e.g., Savannah River, West Valley, Hanford, or Idaho). These organizations will be referred to hereafter as "major participants" in Waste Acceptance Process Activities of high-level waste form production. They are to establish and implement quality assurance programs in accordance

with this specification to assure and demonstrate that canistered waste forms meet the technical and administrative requirements of the Waste Acceptance Specification (WAS). This will include activities associated with: research and development that is essential to qualification of the waste form; control of materials, equipment, facilities, and processes that are essential to the certification of canistered waste forms; and processing operations that are essential to the certification of canistered waste forms.

4.0 DEFINITIONS

The following terms and their definitions are provided to ensure a uniform understanding of these terms as they are used in defining the requirements and guidance contained herein.

4.1 Waste Form - The radioactive waste materials and any encapsulating or stabilizing matrix (10CFR60.2).

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

4.3 Waste Acceptance Process Activities - The activities through which documentation and data are collected and prepared to support compliance with the Waste Acceptance Preliminary Specification. This includes activities associated with: research and development that is essential to qualification of the waste form; control of materials, equipment, facilities, and processes that are essential to the certification of canistered waste forms; and processing operations that are essential to the certification of canistered waste forms.

4.4 Waste Acceptance Specification (WAS) - Identifies the properties and requirements the high-level waste form must meet in order to be accepted for disposal in a Federal Repository.

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

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

4.7 Production Records (PR) - The documentation, provided by the producer, that describes the actual canistered waste forms.

4.8 Computer Code (Scientific and Engineering) - Instructions written in a computer language for the processing of mathematical models developed for use in scientific and engineering analysis, design, safety analysis, process or equipment control and other activities dependent upon a computer for solution or control. Computer code development includes preparation of instructions for the input data format and use of the code.

4.9 Readiness Review - A structured method for determining that an activity is ready to operate or proceed to the next phase, and includes, as a minimum, a comprehensive review of the readiness of the plant and hardware, personnel, and procedures. The review includes a determination of compliance with all requirements.

4.10 Technical Review - A documented, traceable review performed by qualified personnel who are independent of those who performed the work but who have technical expertise at least equivalent to that needed to perform the original work. Technical reviews are in-depth, critical reviews, analyses and evaluations of documents, material or data that require technical verification and/or validation for applicability, correctness, adequacy and completeness that are within the existing state of current technology.

4.11 Peer Review - A documented critical review performed by personnel who are independent of those who performed the work but who have technical expertise at least equivalent to that needed to perform the original work. Peer reviews are in-depth, critical reviews and evaluations of documents, material or data that require interpretation or judgment to verify or validate assumptions, plans, results or conclusions, or material or data contained in a report which generally includes elements that go beyond the existing state of current technology.

4.12 Independent (Personnel) - A condition characterizing an individual or group of individuals who are qualified to analyze, review, inspect, test, audit or otherwise evaluate activities and work results because:

A. They had no direct responsibility for or involvement in performing the activity or work.

B. They are not accountable for the activity or work result.

C. They do not report directly to the immediate supervisors who are responsible for performing the activity or work being evaluated.

4.13 Overview - An analysis and assessment by management of the scope, status, adequacy and effectiveness of quality achievement and assurance activities. Overview encompasses effectiveness assessments, technical reviews, readiness reviews, audits, and surveillances, as appropriate.

4.14 Verification - The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specification requirements. Also, the documented determination that work under review conforms to specified requirements.

4.15 Validation - The documented confirmation of the adequacy (suitability for its intended purpose) of the work under review.

4.16 Indoctrination - To instruct in fundamentals so as to provide understanding of principles involved.

4.17 Training - In-depth instruction to develop proficiency in the application of requirements, methods, and procedures. Such instruction may be internal or external classroom sessions, courses, or informal on-the-job assignments.

4.18 Quality Record - A completed document that furnishes evidence of quality of items and/or activities affecting quality. Lifetime quality records related to waste form production are those quality records that are turned over to the repository operator for preservation as required for the canistered waste form to which they relate.

4.19 Surveillance - The act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

4.20 Audit - A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents, and the effectiveness of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

5.0 REQUIREMENTS

Quality assurance programs are to be established and implemented in Waste Acceptance Process Activities of high-level waste form production. These programs shall contain the activities and meet the criteria for those activities as defined in the basic and supplementary requirements defined hereafter.

5.1 Basic Requirements

The basic quality assurance requirements to be implemented in the quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production are defined in national consensus standards and DOE directives as identified in this section.

5.1.1 National Consensus Standard

(1) ANSI/ASME NQA-1, 1986, "Quality Assurance Program Requirements for Nuclear Facilities," Sections I, II, and III.

This standard contains basic and supplementary requirements and nonmandatory guidance for establishing and implementing quality assurance programs for nuclear facilities. (Note the nonmandatory guidance has not been invoked in the above reference.)

5.1.2 Department of Energy (DOE) Orders and Guidance

(1) DOE 5000.3 "Unusual Occurrence Reporting System"

This directive sets forth policy, responsibilities, criteria, and instructions for preparing, analyzing, and disseminating unusual occurrence reports.

(2) DOE 5700.6B "Quality Assurance"

This directive provides policy, sets forth principles, and designates responsibility for the implementation of DOE plans and actions necessary to ensure quality achievement.

(3) Guidelines for Application of Readiness Reviews to Department of Energy Activities, January, 1987.

This document contains guidelines for planning, staffing and conducting readiness reviews for assuring that all necessary activities and actions have been satisfactorily completed before subsequent activity initiation is authorized.

5.1.3 Relationship to Other Requirements and Guidance

(1) 10 CFR Part 60, "Disposal of High-Level Radioactive Waste in Geologic Repositories." Subpart G, "Quality Assurance," defines basic and supplemental requirements for quality assurance programs for CRWM program participants. Major participants in Waste Acceptance Process Activities of high-level waste form production will fulfill the applicable requirements of 10CFR Part 60, Subpart G, through implementation of quality assurance programs that meet the basic and supplementary requirements defined herein.

(2) DOE/RW-0005, "Mission Plan for Civilian Radioactive Waste Management," Section 5.6, also identifies the basic requirements for quality assurance programs for CRWM program participants. The quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production will implement the applicable requirements of Section 5.6 of DOE/RW-0005 as a consequence of implementing the basic requirements defined herein.

(3) DOE/RW-0032, "OCRWM Quality Assurance Management Policies and Requirements," also identifies basic and supplementary requirements for quality assurance programs for CRWM program participants. The quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production will also implement the applicable requirements of DOE/RW-0032 as a consequence of implementing the basic and supplementary requirements defined herein.

(4) DOE/RW-0043, "Program Management System Manual," Chapter 5, also identifies basic and supplementary requirements for quality assurance programs for CRWM program participants. The quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production will also implement the applicable requirements of Chapter 5 of DOE/RW-0043 as a consequence of implementing the basic and supplementary requirements defined herein.

(5) DOE/RW-0095, "Quality Assurance Plan for High-Level Radioactive Waste Repositories (OGR/B-3)," also identifies basic and supplementary requirements for quality assurance programs for CRWM program participants. The quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production will also implement the applicable requirements of DOE/RW-0095 as a consequence of implementing the basic and supplementary requirements defined herein.

5.2 Supplemental Requirements

There are several areas in Waste Acceptance Process Activities of high-level waste form production in which quality assurance activities are required in addition to those contained in the basic requirements identified in Section 5.1. These activities are identified in this section and the requirements for each activity are defined. These activities, as applicable, are to be developed and implemented as integral parts of the quality assurance programs of major participants in Waste Acceptance Process Activities of high-level waste form production.

5.2.1 Control of Essential Software

Software that is essential to meeting the WAS is to be developed, implemented, documented and controlled as defined hereafter.

A. Software to be controlled shall be identified in the WCP and documented. The documentation shall appropriately reflect the provisions of NUREG-0856 (see Appendix C).

B. Software control activities shall include as appropriate:

(1) Identification of the organization and responsible individuals that influences the quality of software.

(2) Methods and procedures for design and development, including mathematical modeling and technical review of computer codes.

(3) Methods and procedures for verification of computer codes.

(4) Methods and procedures for validation of computer codes.

(5) Methods and procedures for configuration control of computer codes including the user's manual and the computer operations' manual.

(6) Identification of all support software and the computer equipment to be used.

(7) Methods and procedures for reporting, tracking and resolving software problems.

(8) Methods and procedures for safely storing verified computer codes and data.

(9) Methods and procedures for code custody and transfer control.

5.2.2 Peer Review

Peer reviews are to be conducted for items or data significant to Waste Acceptance Process Activities of high-level waste form production. As a minimum, peer reviews shall include activities that go beyond the existing technology or where conclusions or assumptions have not been clearly validated

(e.g., disagreement exists between experts) by conventional means. Such peer reviews are to be identified and are to be planned, conducted and controlled as defined hereafter.

A. Peer reviews shall be accomplished by qualified reviewers having qualifications at least equivalent to that needed to perform the work being reviewed.

B. Peer reviews shall address the following areas as applicable:

(1) Validity of basic assumptions or functional requirements.

(2) Appropriateness of methodology.

(3) Verification of calculations or computer software.

(4) The review process and reviewer responsibilities.

(5) Handling of comment resolutions.

(6) Reporting minority positions.

(7) Involvement of the quality assurance organization.

(8) Review of new documents and changes to previously peer-reviewed documents.

(9) Re-review of revised documents.

(10) Records of revised documents.

(11) Review individual(s) qualifications for the review(s).

C. The need for and extent of additional peer reviews shall be determined and accomplished following the revision of a previously peer-reviewed document whenever the technical content or results presented in the document are revised.

D. Peer review records shall include qualifications of the reviewers, results of the review, and disposition or replies to reviewer comments. The peer review records shall be retained commensurate with the retention requirements of the data or documents which they support.

5.2.3 Control of Experiments and Developmental Activities

Experiments and developmental activities to support Waste Acceptance Process Activities of high-level waste form production are to be controlled and documented in a manner which ensures that:

(1) The data will be suitable for its intended use.

(2) Independent reconstruction and evaluation of the activities can be performed.

A. The controls for experiments and developmental activities shall address the following:

(1) Responsibility for initiating experiments and developmental activity.

(2) Selection and qualification of personnel.

(3) Review and approval of procedures.

(4) Surveillance and auditing of experiments and developmental activities.

(5) Review and evaluation of the results of experiments and developmental activities.

(6) Documentation of experiments and developmental activities and results.

(7) Responsibility for preparation and retention of documentation.

B. While in progress, experiments and developmental activities shall be documented on a day-to-day basis and be maintained in a retrievable form.

C. The experimental or developmental record shall be sufficiently detailed so that the following can be clearly identified, either directly or by reference.

(1) Purpose of the experiment or developmental activity.

(2) The person(s) initiating the experiment or developmental activity.

(3) The person(s) performing the experiment or developmental activity.

D. The experimental or developmental record shall also identify equipment, materials, and procedures actually used in sufficient detail to allow an individual skilled in the technology to reproduce the results.

E. The experimental or developmental record shall also include original records of data or facsimiles of the original records.

F. The experimental or developmental records shall be signed by the person performing the experiment or developmental activity.

G. Any summaries, reports, or evaluations of the experiments, developmental activities or their results that are used for Waste Acceptance Process Activities shall clearly reference the experimental records.

H. The experimental or developmental records of Waste Acceptance Process Activities are to be collected and maintained as quality records.

5.2.4 Qualification of Data

Data or data interpretations in support of Waste Acceptance Process Activities of high-level waste form production are to be acquired or produced under a quality assurance program that meets the requirements defined herein. Data or data interpretations that were generated outside of a quality assurance program, as defined by this document, may be accepted based upon the results of a peer review or may be qualified through corroborating data, confirmatory testing or by having been acquired or produced under an equivalent quality assurance program. Such reviews or other qualification activities are to be conducted as further specified hereafter.

A. Peer reviews shall be performed in accordance with the provisions of Subsection 5.2.2 under a quality assurance program meeting the requirements defined herein.

B. Corroborating data shall be collected, processed and reported to demonstrate the properties of interest (e.g., physical, chemical, scientific, mechanical). Inferences drawn to corroborate non-qualified data shall be clearly identified and presented in a written justification of qualification which includes an analysis of the strengths of the quality assurance program under which the data was developed.

C. Confirmatory tests shall be accomplished in accordance with a quality assurance program meeting the requirements defined herein to demonstrate the properties of interest (e.g., physical, chemical, scientific, mechanical).

D. An equivalent quality assurance program is one that can be shown to be equivalent to the requirements defined herein. A determination of equivalence shall be based upon a demonstration which includes an assessment of differences between the two quality assurance programs and how these differences may bear on the intended use of the data.

E. Documentation generated to support qualification of data shall be collected and maintained as quality records.

5.2.5 Archival of Samples

Archival samples used for waste form qualification or for certification of canistered waste forms are to be prepared and controlled as follows:

A. Sample preparation and use shall be planned and documented. The planning shall identify the following:

(1) What samples are to be used (number, size, origin or other characteristics).

(2) Where and when they are to be taken or prepared.

(3) Where and how they are to be kept.

(4) Where and how they are to be analyzed.

(5) When and how the results are to be used.

B. Methods and procedures for sample preparation, maintenance and use shall be prepared and used. These shall cover the following as a minimum:

(1) Sample taking or preparation.

(2) Logging and labeling or otherwise identifying.

(3) Packing, packaging and handling.

(4) Locating, storage and monitoring.

(5) Retrieval.

(6) Analysis.

(7) Treatment of data and results.

C. Documentation and other forms of evidence necessary to demonstrate the performance of activities essential to the integrity of sample use shall be collected and maintained as quality records.

5.2.6 Control of Special Processes

Production processes that have a significant effect on quality characteristics of the canistered waste form and that produce results that cannot be readily verified by inspection or testing of the final product are to be identified in the WCP and controlled. The controls to be established and implemented on such processes shall be performed by qualified personnel using qualified procedures in accordance with specified requirements and shall include:

A. Process requirements shall be specified and maintained in controlled documentation.

B. Process procedures or instructions shall be prepared and maintained as controlled documents with unique identification and revision status and be readily available in the work area when the process is being performed. These procedures or instructions shall consider the following as a minimum:

(1) Identification of required equipment and instrumentation.

(2) Identification of control parameters and the operating limits for those parameters.

(3) Environmental conditions and requirements.

(4) Instrument calibration frequency.

(5) Reference to applicable codes, standards and specifications.

These procedures or instructions may be included in other controlled documents, such as drawings, checklists, travelers, work orders, or specifications.

C. Personnel shall be selected, trained, and indoctrinated in accordance with subsection 5.2.10.

D. Copies of process requirements, procedures or instructions, and documentation of personnel qualifications shall be collected and maintained as quality records.

5.2.7 Product Certification

The waste form producers are to develop and provide for retention, the records necessary to provide evidence of the acceptability of the canister and waste form which includes the canistered waste form. The WCP and/or WQR are to identify the types of records that will be developed during the waste form production process. The WQR is to identify the quality records required to be a permanent part of the overall canistered waste form product certification package. These documents are to be identified, collected, managed and delivered in accordance with the requirements of subsection 5.2.12.

5.2.8 Readiness Review

Readiness reviews are to be planned, scheduled and conducted at significant transitional events in Waste Acceptance Process Activities leading up to and during high-level waste form production to assure that all necessary activities and actions have been satisfactorily completed before subsequent activity initiation is authorized. Readiness reviews shall be performed in accordance with DOE Guidelines for Application of Readiness Reviews to Department of Energy Activities, dated January, 1987.

5.2.9 Selective Application of Program Activities (Quality Levels)

A systematic method by which quality assurance activities are selected and applied to Waste Acceptance Process Activities of high-level waste form production is to be established and implemented.

The selective application method implemented shall be described in the WCP.

5.2.10 Selection, Indoctrination, and Training of Personnel

Personnel who perform or verify activities affecting quality in waste acceptance process activities of high-level waste form production are to be proficient in the activities that they perform. A systematic practice for achieving and assuring the required proficiency is to be established and implemented. Prior to assigning personnel to perform activities affecting quality, they shall receive appropriate training and indoctrination as defined in ANSI/ASME NQA-1, Supplement 2S-4.

A. Personnel who perform verification activities that require qualification (e.g., lead auditors, inspectors, testers, nondestructive examiners, etc.) are to be certified in accordance with the detailed requirements specified in ANSI/ASME NQA-1 and referenced codes and standards.

B. Other personnel who perform activities that require qualification are to have their qualification requirements defined and their qualifications determined and documented as follows.

1. Types of positions or tasks requiring qualified personnel shall be identified and procedures established for the following:

   (a) Selection of personnel.

   (b) Training and indoctrination of personnel.

   (c) Proficiency evaluation.

   (d) Recording of qualifications.

2. Position or task descriptions shall be prepared which define the minimum education and experience requirements for each type of position or task requiring qualification.

3. Personnel selected to fill positions or perform tasks requiring qualification shall be evaluated to determine that they are qualified. Such determinations shall be documented by managers or supervisors responsible for the activities to be performed.

5.2.11 Overview of Quality Assurance Activities

Each major participant in Waste Acceptance Process Activities of high-level waste form production is to establish and implement a systematic overview of quality assurance activities performed by organizations over which they have contractual or administrative overview responsibilities. Each organization's overview practice is to include an appropriate combination of the following activities:

(1) The review and approval of participant quality assurance plans and administrative procedures.

(2) Surveillance of participant activities affecting quality to verify compliance with requirements.

(3) Performance of quality assurance audits to verify the adequacy and effectiveness of participant quality assurance program activities.

These activities are to be planned and performed in accordance with procedures as described hereafter:

A. Procedures shall be established for the review of participant quality assurance programs to verify adequacy, completeness and relevance. The overview procedures shall identify the types of documents to be submitted by the participant for review and approval; shall assign project responsibility for reviews; and shall identify the methods for documenting review and approval actions.

B. Procedures shall be established for planning, scheduling, performing, and documenting surveillance of participant activities related to quality. Surveillance activities shall be performed by personnel who are not directly responsible for performing the work to be monitored or observed in the surveillance activity. Surveillance actions shall be performed to written checklists or plans whenever practicable. All deficiencies, non-conformances and potential quality problems identified during the surveillance shall be documented and monitored until verification of disposition or corrective action is accomplished.

C. Procedures shall be established for the planning, scheduling, performing and reporting of quality assurance audits of participant quality assurance programs. Audit schedules shall be developed annually and updated as changes occur. Audits of organizations common to more than one project shall be coordinated whenever practicable to conserve resources and maintain consistency.

Audit teams should include, whenever possible, a representative that is trained and/or qualified in the technology being audited.

D. Documentation of overview activities shall be retained as quality records.

5.2.12 Quality Records

Documentation sufficient to demonstrate canistered waste form compliance with the WAS and implementation of this specification is to be prepared and maintained as quality records. These records are to be collected and maintained as follows.

A. Documentation sufficient to demonstrate satisfactory implementation of the WCP shall be collected and maintained as lifetime quality records by the major participant that generated or caused to be generated the documentation. Copies of these records shall be made available to the Federal Repository Operator at the time the repository is ready to begin accepting canistered waste forms from the waste form producer. Such records will be maintained by the Federal Repository Operator to satisfy any repository requirements. Other documentation generated during preparation and implementation of the WCP shall be collected and maintained as nonpermanent quality records.

B. Documentation sufficient to support preparation of the WQR shall be collected and maintained as lifetime quality records by the major participant that generated or caused to be generated the documentation. Copies of these records shall be made available to the Federal Repository Operator at the time the repository is ready to begin accepting canistered waste forms from the waste form producer. Such records will be maintained by the Federal Repository Operator to satisfy any repository requirements. Other documentation generated during preparation and maintenance of the WQR shall be collected and maintained as nonpermanent quality records.

C. Production documentation shall be identified in a manner that facilitates positive-direct correlation between documents and canistered waste forms to which they relate.

D. Production documentation shall be declared lifetime quality records and transferred to the Federal Repository Operator with the canistered waste forms to which they relate.

E. Copies of production documentation shall be kept and maintained by the waste form producer as non-permanent quality records. These records shall be kept for a minimum of 10 years after the canistered waste forms they represent are transferred to the Federal Repository Operator or as otherwise directed by DOE.

5.2.13 Modification Control

Controls are to be established and implemented by the appropriate major participant to assure that only approved modifications are made in Waste Acceptance Process Activities of high-level waste form production. These controls shall include the following:

A. Application to items and activities that are essential to canistered waste form certification and acceptance as defined in the WAS including the following as appropriate.

(1) The waste form.

(2) The waste canister.

(3) The canistered waste form.

(4) The production process.

(5) Processing equipment.

(6) Processing supplies and consumables.

(7) Processing plans and procedures.

(8) Maintenance plans and procedures.

(9) Process control plans and procedures.

B. A controlled listing of the documentation that defines items and activities under modification control.

C. Procedures defining elements of the modification control process that address:

(1) Change proposals (including deviation requests and waiver request).

(2) Change review and approval.

(3) Change implementation.

(4) Change incorporation and issue of changed documentation and records.

D. Provisions for assessing the need for and accomplishing any needed requalification resulting from modifications.

5.2.14 Effectiveness Evaluation

Each major participant in Waste Acceptance Process Activities of high-level waste form production is to establish and implement methods and procedures for evaluating the effectiveness of its quality assurance program in ensuring conformance with the WAS. The effectiveness evaluation practice is to include the following:

A. A clear identification of the quality characteristics to be achieved in meeting the requirements of the WAS.

B. The identification of an appropriate set of performance indicators that reflect actual quality characteristics being achieved.

C. A performance measuring process using review, surveillance, inspection, tests, audit or other techniques to monitor performance indicators.

D. An analysis process in which performance data are trended and problem areas identified.

E. A reporting practice in which program effectiveness information is prepared and fed back to top management.

5.3 Quality Assurance Program Description

The quality assurance program applied to Waste Acceptance Process Activities of high-level waste form production is to be described in a document that provides guidance and direction for program implementation and a concise description of what the program contains and how it is to function.

5.3.1 General

A. The description shall cover the basic and supplementary requirements identified in Sections 5.1 and 5.2 of this specification in sufficient detail to provide a

knowledgeable reviewer with confidence that an adequate response to all quality assuance requirements have been identified and fully developed in the quality assurance program.

B. The description shall also provide a formal statement by the management of the organization of its commitment to:

(1) Implement the quality assurance program activities for which it is responsible.

(2) Review the program periodically and revise it as necessary to keep it current and effective.

5.3.2 Structure

The program description is to be a composite of the program descriptions of each of the major participants in Waste Acceptance Process Activities of high-level waste form production tied together by an umbrella description that identifies the major participants, their roles and responsibilities and how they interface and work together. This structural concept is illustrated in Figure 1. Figure 2 shows how such a waste form producer program description can be used to support The Federal Repository's licensing activities.

5.3.3 Format and Content

The format and content of each of the constitutent program descriptions of the major participants are to be as described in Appendix A, Guidelines for Preparation of a Quality Assurance Program Description for High-Level Waste Form Production.

5.3.4 Approval and Maintenance

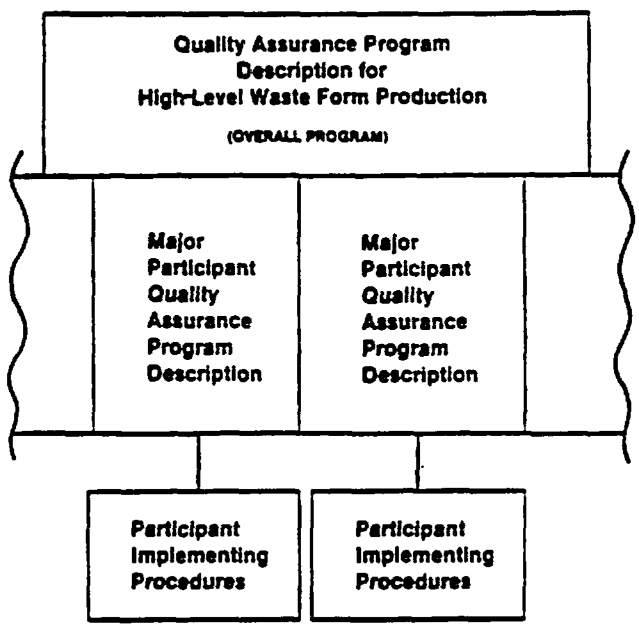
A. The program description is to be made a part of the WCP.

B. Procedures shall be prepared and implemented for the program description approval and subsequent change control that satisfy DOE approval and change control requirements. These procedures may be an integral part of the procedures for approval and maintenance of the WCP or they may be separate.

5.4 Program Description Evaluation

Quality assurance programs applied to Waste Acceptance Process Activities of high-level waste form production are expected to be evaluated by DOE/RW, as the repository licensing applicant, for licensing purposes against the applicable criteria of the NRC Review Plan for Quality Assurance Programs for High-Level Nuclear Waste Repositories (HLNWR). To ensure the acceptability of these quality assurance programs, the program descriptions prepared as defined in Section 5.3 of this specification shall be evaluated against the criteria in Appendix B, Review Plan for Quality Assurance Programs for High-Level Waste Form Production. As a minimum, this evaluation shall be performed as an internal evaluation by the organization preparing the program description. Alternatives to the Appendix B criteria may be necessary to address unique HLNWR situations. They shall be identified and justified in the WCP. The quality assurance program description in the WCP shall address any modifications to the criteria of Appendix B.

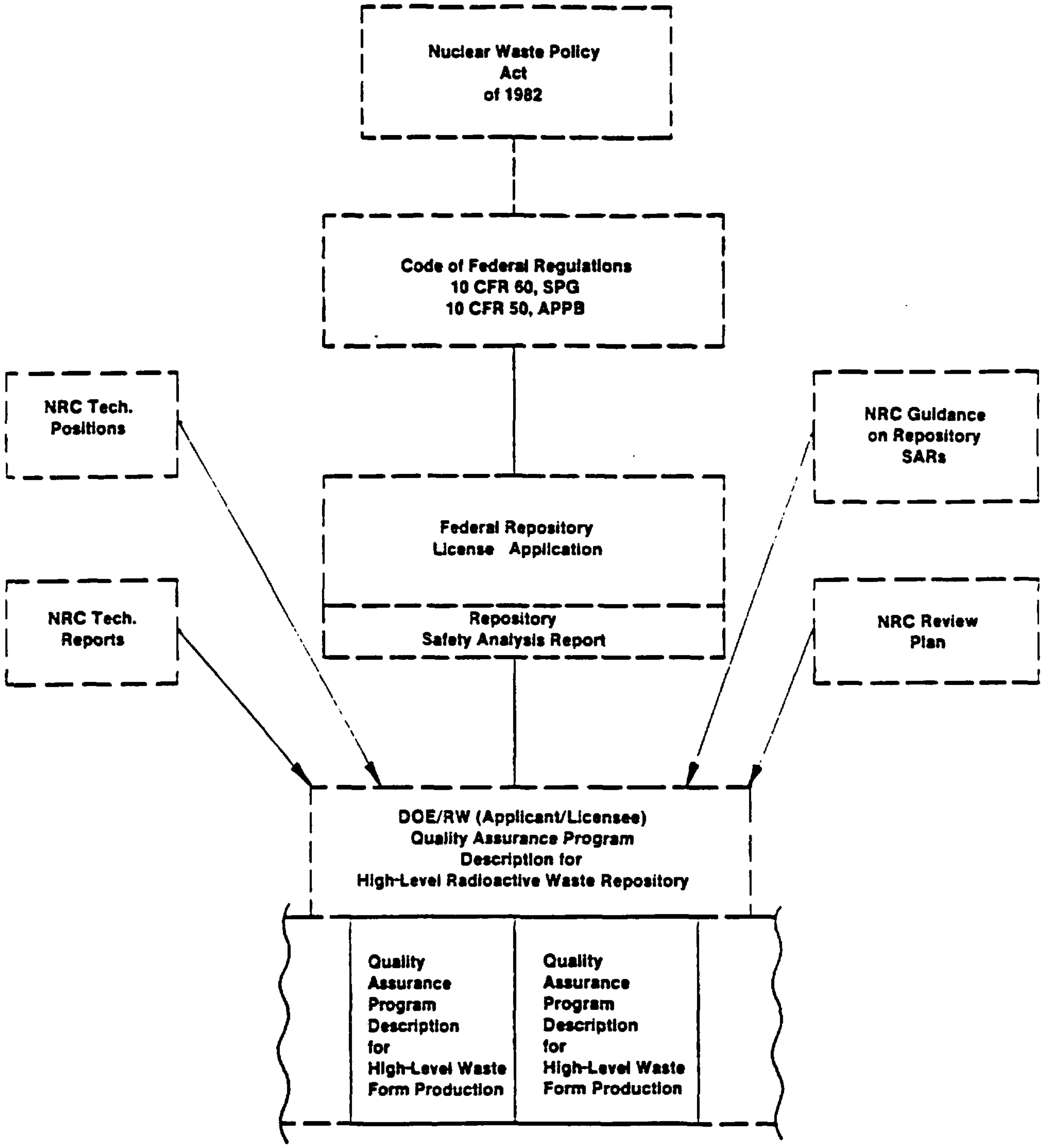
COMPOSITE QUALITY ASSURANCE PROGRAM DESCRIPTION FOR A TYPICAL HIGH-LEVEL WASTE FORM PRODUCTION ACTIVITY



Major Participants (High-Level Waste Form Production)

- DOE-HQ
- DOE-OPS Office
- DOE-PO
- OP Contractor

FIGURE 1



TYPICAL RELATIONSHIP OF QUALITY ASSURANCE
PROGRAM DESCRIPTIONS TO SUPPORT REPOSITORY LICENSING

FIGURE 2

APPENDICES

APPENDIX A

GUIDELINES
FOR
PREPARATION OF A QUALITY ASSURANCE PROGRAM DESCRIPTION
FOR
HIGH-LEVEL WASTE FORM PRODUCTION

1.0 INTRODUCTION

This appendix has been prepared as a guide to assist high-level waste form producer organizations in the preparation of their quality assurance program descriptions in response to the requirements of Section 5.3 of this specification. The quality assurance program described in the program description is intended to be the program implemented in Waste Acceptance Process Activities of high-level waste form production. The program described may be more broadly applied if the organization wishes and such expanded scope should be clearly identified in such a way as to make it very clear as to which activities apply to Waste Acceptance Process Activities of high-level waste form production and which activities are applied beyond that scope.

The guidance contained in this appendix is a customized version of NRC Regulatory Guide 1.70.6. The guide was developed by NRC many years ago to assist applicants with water reactor construction projects in the preparation of their quality assurance program descriptions. These descriptions were intended to be included in license applications as Chapter 17 of The Safety Analysis Report. At that time NRC required the applicant to prepare its description in the format (including paragraph numbering and titles) as shown in the guide. For this reason the guide has been left showing the Chapter 17 format as though the resulting program description would become a part of Chapter 17 in The Safety Analysis Report of the repository license application.

17.0 QUALITY ASSURANCE

The quality assurance program being described should be established at the earliest practical time consistent with the schedule for accomplishing the activity. Where some portions of the quality assurance program have not yet been established at the time the Program Description is prepared, (because the activity will be performed in the future) the description should also provide a schedule for implementation.

In order to facilitate the presentation of information about the quality assurance program, the major participants in the waste form producer organization that are involved in executing the quality assurance program should include the information described (either separately for each organization or integrally for all organizations) in accordance with the outline presented below.

17.2 Quality Assurance During Production

17.2.1 Organization

17.2.1.1 The Program Description should describe clearly the authority and duties of persons and organizations performing the quality assurance functions of assuring that the quality assurance program is established and executed and of verifying that an activity has been correctly performed. The Program Description should provide organization charts and functional responsibility descriptions that denote the lines of responsibility and areas of authority within each of the major participant organizations in Waste Acceptance Process Activities of high-level waste form production including DOE headquarters, DOE operation offices, DOE project offices, and operating contractors of DOE facilities. Hereafter, these organizations are referred to collectively as the "waste form producer". These charts and descriptions should present the structure of quality assurance organizations involved as well as other functional organizations performing activities affecting quality in preparation of waste forms, acquisition of waste canisters and canistering of waste forms with clear delineation of their responsibility, authority, and relationship to corporate management. In addition, a single, overall project organization chart should be included showing how the major organizations or companies working directly as the waste form producer interrelate with one another.

17.2.1.2 The Program Description should describe the level of management responsible for establishing the quality assurance policies, goals, and objectives and should describe the continuing involvement of this management level in quality assurance matters. The Program Description should tell what position has overall authority and responsibility for the quality assurance program and tell what position is responsible for final review and approval of the quality assurance program and related manuals. The qualification requirements of the principal quality assurance and quality control positions should be described.

17.2.1.3 The Program Description should describe those measures which assure that persons and organizations performing quality assurance functions have sufficient authority and organizational freedom to (1) identify quality problems, (2) initiate, recommend, or provide solutions, and (3) verify implementation of solutions. The Program Description should describe the measures which assure that persons and organizations assigned the reponsibility for checking, auditing, inspecting or otherwise verifying that an activity has been correctly performed report to a management level such that this required authority and organizational freedom, including sufficient independence from the pressures of production, are provided. Irrespective of the organizational structure, the Program Description should describe how the individual or individuals with primary responsibility for assuring effective implementation of the quality assurance program at any location where activities subject to the control of the quality assurance program are being performed will have direct access to such levels of management as may be necessary to carry out this responsibility. The Program Description should indicate from whom the persons performing quality assurance functions receive technical direction for performing quality assurance

tasks and administrative control (salary review, hire/fire, position assignment). The Program Description should identify those positions or organizations which have written delegated responsibility and authority to stop work or control further processing, use or delivery of nonconforming items until proper disposition of the deficiency has been approved.

The Program Description should describe how requirements will be imposed on other organizations including contractors and subcontractors to assure that individuals or groups within their organizations performing quality assurance functions have sufficient authority and organizations freedom to effectively implement their respective quality assurance programs.

17.2.1.4 The Program Description should describe the extent to which the organization will delegate to other organizations the work of establishing and executing the quality assurance program or any part thereof. A clear delineation of those quality assurance functions which are implemented within the organization and those which are delegated to other organizations should be provided in the Program Description. The Program Description should describe the method by which the organization will retain responsibility for and maintain control over those portions of the quality assurance program delegated to other organizations and should identify the organization responsible for verifying that delegated quality assurance functions are properly carried out. The Program Description should identify major work interfaces for activities affecting quality and describe how clear and effective lines of communication exist between the organization and other major participants in the waste form producer organization to assure necessary coordination and control of the quality assurance program.

17.2.2 Quality Assurance Program

17.2.2.1 The quality assurance program in the Program Description should cover each of the criteria in Appendix B to 10 CFR Part 50 (see Note 1) in sufficient detail to permit a determination as to whether and how all of the requirements of Appendix B will be satisfied. The Program Description should (1) describe the extent to which the quality assurance program will conform to various provisions of ANSI/ASME NQA-1 and NRC regulatory guides that provide guidance on acceptable methods of implementing portions of the quality assurance program and (2) identify the organizational element responsible for implementing these provisions. If the waste form producer elects not to follow the above guidance, the Program Description should describe in detail equivalent to that furnished in this instruction the alternative methods that will be used and the manner of implementing them and should indicate the organizations responsible for their implementation.

Note 1 - The Federal Repository including the waste package to be placed in the repository is to comply with 10CFR Part 60. Subpart G of this regulation subsequently requires compliance with Appendix B of 10CFR Part 50.

17.2.2.2 The Program Description should identify the items and activities of the Waste Acceptance Process Activities of high-level waste form production to be controlled by the quality assurance program.

17.2.2.3 The Program Description should describe the measures which assure that the quality assurance program was or is being established at the earliest practicable time consistent with the schedule for accomplishing activities affecting quality in Waste Acceptance Process Activities of high-level waste form production. That is, the Program Description should describe how the quality assurance program is being established in advance of the activity to be controlled and how it will be implemented as the activity proceeds. Those activities affecting quality initiated prior to the development of the waste form producer Quality Assurance Program, such as establishing information required to be included in the Program Description; performing research and development that is essential to the qualification of the waste form; control of materials, equipment, facilities, and processes that are essential to the certification of canistered waste forms; and processing operations that are essential to the certification of canistered waste forms should be identified in the Program Description. The Program Description should describe how these activities are controlled by a quality assurance program which complies with this specification.

17.2.2.4 The Program Description should describe how the quality assurance program is documented by written policies, procedures, or instructions and how it will be implemented in accordance with these policies, procedures, or instructions. The procedures list should identify which requirements of the specification are implemented by each procedure. In the event certain required procedures are not yet established, a schedule for their preparation should be provided in the Program Description.

17.2.2.5 The Program Description should summarize the corporate quality assurance policies, goals, and objectives; and it should describe how disputes involving quality are resolved.

17.2.2.6 The Program Description should describe the program that provides adequate indoctrination and training of personnel performing activities affecting quality in Waste Acceptance Process Activities of high-level waste form production to assure that suitable proficiency is achieved and maintained. The Program Description should describe how the indoctrination and training program will assure that:

1. Personnel performing activities affecting quality are appropriately trained in the principles and techniques of the activity being performed,

2. Personnel performing activities affecting quality are instructed as to purpose, scope, and implementation of governing manuals, policies, and procedures,

3. Appropriate training procedures are established, and

4. Proficiency of personnel performing activities affecting quality is maintained.

17.2.2.7 The Program Description should describe the qualification requirements for the position or positions responsible for assuring effective implementation of the quality assurance program of the major participants in the waste form producer organization.

17.2.2.8 The Program Description should describe the measures that assure that activities affecting quality will be accomplished under suitable controlled conditions, including (1) the use of appropriate equipment, (2) a suitable environment for accomplishing the activity; e.g., adequate cleanliness, and (3) compliance with necessary prerequisites for the given process or activity.

17.2.2.9 The Program Description should describe the measures that assure that there is regular management review of the quality assurance program to assess its effectiveness and the adequacy of its scope, and implementation. The Program Description should describe the provisions for reviews by management above or outside the quality assurance organization to assure achieving an objective program assessment. The Program Description should describe the measures that assure that the quality assurance unit of the organization will (1) review and document agreement with the quality assurance programs of subtier participants in the waste form producer organization and (2) conduct or have conducted audits of the subtier participants.

17.2.2.10 The Program Description should provide a summary description of the advanced planning that demonstrates control of quality-related activities including management and technical interfaces between the participant and other major participants in the waste form producer organization during research and development that is essential to qualification of the waste forms; control of materials, equipment, facilities, and processes that are essential to the certification of canistered waste forms; and processing operations that are essential to the certification of canistered waste forms.

17.2.2.11 The Program Description should describe provisions for maintaining the quality assurance Program Description current.

17.2.3 Design Control

17.2.3.1 The Program Description should describe the design control measures that assure that (1) applicable requirements for important items and activities essential to the certification of canistered waste forms are correctly

translated into operating and production processing specifications, drawings, procedures, and instructions, or for any modifications that become necessary, (2) appropriate quality standards are specified in design documents, and (3) deviations from such standards are controlled.

17.2.3.2 The Program Description should describe measures to control operations, maintenance and modifications that assure that adequate review and selection for application suitability is conducted for production materials, parts, equipment, and processes that affect features of the canistered waste form with regard to its conformance with the Waste Acceptance Specification (WAS). The Program Description should describe provisions that assure that standard commercial or so-called "off-the-shelf" materials, parts, and equipment also receive adequate application review and selection before use in production processing that could affect canistered waste form compliance with the WAS.

17.2.3.3 The Program Description should describe the program for applying design control measures to such aspects of production as processing; process design, development and qualification; production materials compatibility; product design, inspection, and testing and should describe measures for delineation of acceptance criteria for inspections and tests.

17.2.3.4 The Program Description should describe measures that assure verification or checking of design adequacy, such as by design reviews, use of alternative calculational methods, or performance of a qualification testing program under the most adverse design conditions. The Program Description should identify the positions or organizations responsible for design verification or checking and should describe how design verification or checking is performed by individuals or groups other than those who performed the original design, but who may be from the same organization.

17.2.3.5 The Program Description should describe measures for identifying and controlling design interfaces, both internal and external, and for coordination between participating design organizations. The Program Description should describe measures in effect between participating design organizations for review, approval, release, distribution, collection, and storage of documents involving design interfaces and changes thereto. The Program Description should describe how these measures will assure that these design documents are controlled in a timely manner to prevent inadvertent use of superseded design information.

17.2.3.6 The Program Description should describe the measures that will be employed to assure that design changes, including field changes, are subject to the same design controls that were applied to the original design and are reviewed and approved by the organization that performed the original design unless the originating organization designates another responsible organization.

17.2.4 Procurement Document Control

17.2.4.1 The Program Description should describe measures that assure that documents, and changes thereto, for procurement of material, equipment, and services, whether purchased by the waste form producer or contractors or subcontractors, correctly include or reference the following as necessary to achieve required quality:

1. Codes, standards and design requirements,
2. Quality assurance program requirements,
3. Requirements for supplier documents such as instructions, procedures, drawings, specifications, inspection and test records, and supplier QA records to be prepared, submitted, or made available for purchaser review or approval,
4. Requirements for the retention, control, and maintenance of supplier quality assurance records,
5. Provision for purchaser's right of access to supplier's facilities and work documents for inspection and audit, and
6. Provision for supplier reporting and disposition of nonconformances from procurement requirements.

17.2.4.2 The Program Description should describe (1) measures that clearly delineate the control responsibilities and action sequence to be taken in the preparation, review, approval, and issuance by competent personnel of procurement documents and (2) measures that assure that changes or revisions of procurement documents are subject to the same review and approval requirements as the original documents.

17.2.4.3 The Program Description should describe measures that assure (1) that procurement documents require suppliers to have and implement a documented quality assurance program for purchased materials, equipment, and services to an extent consistent with their importance, (2) that the purchaser has evaluated the supplier before the award of the purchase order or contract to assure that the supplier can meet the procurement requirements, and (3) that procurement documents for spare or replacement items will be subject to controls at least equivalent to those used for the original supplies or equipment.

17.2.5 Instructions, Procedures, and Drawings

17.2.5.1 The Program Description should describe measures that assure that activities affecting quality such as production processing, equipment maintenance, modifications, repair, testing, and inspection, and product handling are prescribed by appropriately documented instructions, procedures, or drawings and that these activities will be conducted in accordance with these documents.

17.2.5.2 The Program Description should describe the system whereby the documented instructions, procedures, and drawings will include appropriate quantitative (such as dimensions, tolerance, and operating limits) and qualitative (such as workmanship samples) acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

17.2.6 Document Control

17.2.6.1 The Program Description should describe those measures established to control the issuance of documents such as instructions, procedures, and drawings, including changes thereto, that prescribe all activities affecting quality in Waste Acceptance Process Activities of high-level waste form production. The description should cover control measures that assure that:

1. Documents are reviewed for adequacy (i.e., information is clearly and accurately stated) and are approved by authorized personnel for issuance and use at locations where the prescribed activity will be performed before the activity is started,

2. Means such as use of updated master document lists exist to assure that obsolete or superseded documents are replaced in a timely manner by updated applicable document revisions, and

3. Document changes are reviewed and approved by the same organizations that performed the original review and approval unless delegated by the originating organization to another responsible organization.

17.2.6.2 The Program Description should identify the types of documents to be controlled and the group responsible for review, approval, and issuance of documents and changes thereto.

17.2.7 Control of Purchased Material, Equipment, and Services

17.2.7.1 The Program Description should describe those measures that assure that material, equipment, and services purchased directly by the waste form producer or subcontractors will conform to procurement document requirements. The Program Description should describe the measures that provide, as appropriate for:

1. Evaluation and selection of sources of supply before the award of the procurement order or contract,

2. Surveillance at the supplier's facility by the purchaser or his representative in accordance with written procedures during design, manufacture, inspection, and test of the procured item or service to verify compliance with quality requirements,

3. Source and/or receipt inspection in accordance with written procedures and acceptance criteria of procured items furnished by the supplier,

4. Documentary evidence at the production facility from the supplier that procured items meet procurement quality requirements such as codes, standards, or specifications. The Program Description should describe measures established by waste form producer to (a) examine and indicate acceptance of this documented evidence during source or receipt inspection and (b) assure that this documented evidence is available at the production facility prior to installation or use of the procured item and that the documentation will be retained at the production facility, and

5. Periodic verification of supplier's certificates of conformance to assure that they are meaningful.

17.2.7.2 The Program Description should describe measures whereby the waste form producer or his designated representative will audit and evaluate the effectiveness of the control of quality related activities of contractors and subcontractors at a frequency and extent consistent with the importance to safety, complexity, and quantity of the item or service being furnished.

17.2.8 Identification and Control of Materials, Parts, and Components The Program Description should describe measures established to identify and control processing materials, supplies, canisters, canistered waste forms, including partially filled assemblies, to prevent use of incorrect or defective feed material or loss of tracability between canistered waste forms and documentation. The Program Description should describe measures that assure (1) that identification of the item (i.e., heat number, part number, serial number, or other appropriate marking) is maintained either on the item or on records traceable to the item and verified, as required, throughout production, processing and (2) that the method and location of the identification does not affect the function or quality of the item being identified.

17.2.9 Control of Special Processes The Program Description should describe measures established to control special processes such as glass melting, welding, cleaning, and testing and to assure that they are accomplished by qualified personnel using written procedures qualified in accordance with applicable codes, standards, specifications, or other special requirements. The Program Description should describe those measures that assure that qualifications of special processes, personnel performing special processes, and equipment are kept current and that record files thereof are maintained.

17.2.10 Inspection

17.2.10.1 The Program Description should describe the measures that assure that a program for inspection is established and implemented by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. The Program Description should describe measures that assure that (1) inspection personnel are appropriately qualified and are independent of the individual or group performing the activity being inspected, (2) inspections or tests are performed for each work operation or process activity as necessary to verify quality, (3) indirect control by monitoring processing methods, equipment, and personnel is used if direct inspection of processed material or products is impossible or disadvantageous, and (4) both inspection and process monitoring are used when control is inadequate without both. The Program Description should describe measures that assure that (1) inspection procedures and instructions are made available with necessary drawings and specifications for use prior to performing the inspections, (2) inspectors' qualifications or certifications are kept current, (3) replaced or reworked items are inspected in accordance with original inspection requirements, and (4) modified or repaired items are inspected by methods that are equivalent to the original inspection method.

17.2.10.2 The Program Description should describe the system whereby appropriate documents will identify any mandatory sampling or inspection hold-points that require witnessing or inspecting by the waste form producer or his designated representative and beyond which work may not proceed without the consent of his designated representative.

17.2.11 Test Control

17.2.11.1 The Program Description should describe the measures that establish a test program that (1) identifies all testing required to demonstrate that items and services will conform to specified requirements, (2) is conducted by trained and appropriately qualified personnel in accordance with written test procedures that incorporate or reference the requirements and acceptance limits contained in applicable design documents, and (3) includes testing that will be performed in the Product and Process Qualification Phases.

17.2.11.2 The Program Description should describe the measures that assure test procedures have provisions for assuring that:

1. All prerequisites for the given test have been met,

2. Adequate instrumentation and equipment are available, and

3. The test is performed under suitable environmental conditions and with appropriate test methods.

17.2.11.3 The Program Description should describe the system whereby test results are documented and evaluated to assure that test requirements have been satisfied.

17.2.12 Control of Measuring and Test Equipment

The Program Description should describe the measures established to assure that tools, gauges, instruments, and other measuring and testing devices used in activities affecting quality are properly identified, controlled, adjusted, and calibrated at specified periods to maintain accuracy within necessary limits. The Program Description should describe measures that assure (1) that these devices are adjusted and calibrated against certified equipment or reference transfer standards having known valid relationships to nationally recognized standards or (2) that if no national standards exist, the basis for calibration is documented. The Program Description should describe the measures that assure that the error of calibration standards is less than the error of production measuring and test equipment. The Program Description should describe provisions that will apply if measuring and test equipment is found out of calbration (1) for evaluating the validity of previous inspection or test results and the acceptability of items inspected or tested since the last calibration check and (2) for repeating original inspections or tests using calibrated equipment where necessary to establish acceptability of suspect items. The Program Description should describe measures that assure the maintenance of records that indicate the calibration status of all items under the calibration system and that identify the measuring and test equipment.

17.2.13 Handling, Storage, and Shipping

The Program Description should describe the measures established to control the handling, storage, shipping, cleaning, and preservation of canistered waste forms including processing material and equipment in accordance with work and inspection instructions to prevent damage or deterioration. The Program Description should describe the measures for specifying and providing, when necessary for particular process steps, special protective environments such as inert gas atmosphere, specific moisture content levels, and temperature levels.

17.2.14 Inspection, Test, and Operating Status

The Program Description should describe measures established to indicate by the use of markings such as stamps, tags, labels, routing cards, or other suitable means the status of inspections and tests performed on individual items or activities of the canistered waste form throughout waste form production. The Program Description should describe measures that provide for the identification of items and services that have satisfactorily passed required inspections and tests where necessary to preclude inadvertent bypassing of such inspections and tests. The Program Description should describe the measures established for indicating the operating status of structures, systems, and components of the processing equipment and its support facilities and equipment. Such measures shall include, for example, tagging valves and switches to prevent inadvertent operation.

17.2.15 Nonconforming Materials, Parts, or Components

The Program Description should describe the measures established to control materials, parts, components or canistered waste forms that do not conform to requirements in order to prevent their inadvertent use or delivery. The Program Description should describe measures that provide for, as appropriate, identification, documentation, segregation, disposition, and notification to affected organizations. The Program Description should describe measures that assure that nonconforming items are reviewed and dispositioned in accordance with documented procedures. The Program Description should describe measures that control further processing or delivery pending proper disposition of the deficiency. The Program Description should describe measures established by the waste form producer (1) for contractors to report to him those nonconformances concerning departures from procurement requirements that are dispositioned "use as is" or "repair" and (2) to make such nonconformance reports part of the documentation required at the waste form production site or to include description of the nonconformance and its disposition on certificates of conformance that are provided to the site prior to use of material or equipment. The Program Description should state whether periodic analyses of nonconformance reports are performed to show quality trends and whether such analyses are forwarded to management.

17.2.16 Corrective Action

17.2.16.1 The Program Description should describe the measures that assure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconforming in process and completed products are promptly identified and corrected.

17.2.16.2 The Program Description should describe how, in the case of significant conditions adverse to quality, the cause of the condition is determined, corrective action is taken to preclude repetition, and the problem with its determined cause and corrective action is documented and reported to appropriate levels of management.

17.2.17 Quality Assurance Records

17.2.17.1 The Program Description should describe the measures that assure that sufficient records are maintained to furnish evidence of activities affecting quality. The Program Description should describe how the content of such records (1) includes at least the following: test logs; results of reviews, drawings, inspections, tests, audits, monitoring of work performance, and materials and product analyses; and such data as qualifications of personnel, procedures, and equipment; (2) identifies the type of operation, and inspector or data recorder, the results, the acceptability, and action taken to correct any deficiencies noted; and (3) provides sufficient information to permit identification of the record with the item or activity to which it applies.

17.2.17.2 The Program Description should describe the measures that assure that records will be identifiable and retrievable.

17.2.17.3 The Program Description should describe the measures that establish requirements (consistent with regulatory requirements and responsibilities concerning record submittal and retention, security, and storage facilities) for protecting records from destruction by fire, flooding, tornadoes, insects, and rodents and from deterioration by extremes in temperature and humidity.

17.2.18 Audits

The Program Description should describe the program of the waste form producer for conducting comprehensive planned and periodic audits to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program.

The Program Description should describe the program features that cover the functions listed below and should identify the positions or organizations that perform these functions.

1. External audits to be performed by the waste form producer or suppliers,

2. Internal audits to be performed by the waste form producer within their respective organizations,

3. The planning and scheduling of audits to assure that they are regularly scheduled on the basis of the status and safety importance of the activities being performed and are initiated early enough to assure effective quality assurance during production processing; equipment maintenance, modification, repair, inspection, and testing; or product inspection, handling, storing and shipping.

4. Conduct of audits in accordance with written procedures or checklists by appropriately trained and qualified personnel not having direct responsibility in the area being audited, and

5. Documentation of audit results with review by management responsible for the area audited and, where indicated, followup action taken, including re-audit of the deficient areas.

APPENDIX B

REVIEW PLAN

FOR

QUALITY ASSURANCE PROGRAMS FOR HIGH-LEVEL WASTE FORM PRODUCTION

1.0 INTRODUCTION

This appendix has been prepared for use by organizations that are major participants in Waste Acceptance Process Activities of high-level waste form production. It is intended to be used as a checklist or review plan for evaluating the adequacy of the organization's quality assurance program in meeting the requirements for that program as defined in this specification. Its purpose is to facilitate the program evaluation required by Subsection 5.4 of this specification.

The quality assurance program required by this specification is expected to be evaluated at some point in the Federal Repository licensing procedure by the NRC. In order to develop the highest confidence level possible in its being found acceptable by the NRC at that time, this checklist or review plan has been prepared using the NRC's review plans for quality assurance programs for nuclear facility design, construction, and operations; repository site characterization; and waste packaging and transportation. Also considered were generic technical positions and other guidance that has been made available from the NRC. Since the evaluation by the NRC is expected to be made using their review plan for quality assurance programs for High-Level Nuclear Waste Repositories (HLNWR), this checklist or review plan has been prepared using concepts and language similar to that which would be expected to be in the NRC's review plan. Further, since the NRC's review plan is expected to be strongly oriented toward repository design, construction and operation, the checklist or review plan contained herein is also oriented in language to facility design, construction and operation even though the intended scope and application of the required quality assurance program is strictly Waste Acceptance Process Activities of high-level waste form production. This bias has been purposefully placed in the checklist or review plan to cause the evaluation process by the major participant's organization to consider the features of the program description from the same reference points expected of the NRC evaluation.

2.0 GENERAL

The quality assurance program description must describe the quality assurance program that will be established, maintained, and implemented in the accomplishment of Waste Acceptance Process Activities of high-level waste form production.

The required quality assurance program is to be described in sufficient detail to allow a review and determination of acceptability with regard to the acceptance criteria defined herein.

3.0 ACCEPTANCE CRITERIA

These acceptance criteria are to be used to evaluate the quality assurance program of a waste form producer that is proposed for accomplishing Waste Acceptance Process Activities of high-level waste form production.

The evaluation is to also determine if the implementation of commitments to specified requirements has been described in inspectable terms.

I. The organizational elements responsible for the quality assurance program are acceptable if:

   A. The responsibility for the overall program for Waste Acceptance Process Activities of high-level waste form production is retained and exercised by the appropriate DOE organization.

   B. The waste form producer describes any delegation of work involved in establishing and implementing the quality assurance program.

   C. The waste form producer evaluates the performance of delegated work.

   D. Qualified individual(s) or organization(s) within the waste form producer's organization are responsible for the quality of work prior to initiation of activities.

   E. The waste form producer has established effective lines of communication between participants for quality assurance activities.

   F. Organization charts clearly identify all organizational elements which function under the cognizance of the quality assurance program and identifies the lines of responsibility.

   G. The quality assurance responsibilities of organizational elements are described.

   H. The quality assurance organization is involved in the aspects of Waste Acceptance Process Activities of high-level waste production that affects safety-related and waste isolation features of canistered waste forms.

   I. The waste form producer identifies the management position that retains the overall responsibility and authority for the quality assurance program.

   J. Verification of conformance to established requirements is accomplished by individuals or groups within the quality assurance organization.

K. Persons or organizations performing quality assurance functions are identified and have direct access to management levels which will assure the ability to:

   1. Identify quality problems.

   2. Initiate, recommend or provide solutions through designated channels.

   3. Verify implementation of solutions.

   4. Stop or control further execution of unsatisfactory work.

   These responsibilities are designated in writing.

L. Provisions are established for the resolution of disputes involving quality arising from differing opinions between quality assurance and other participating organizations.

M. Policies regarding quality assurance program implementation are documented and mandatory.

II. Activities related to the <u>quality assurance program</u> are acceptable if:

A. The quality assurance program includes all Waste Acceptance Process Activities of high-level waste form production associated with features of the waste form and canistered waste form that are important to safety or waste isolation. The rationale is provided for determining how the items or activities were identified.

B. The quality assurance program includes a commitment that control and use of computer software will be conducted in accordance with the quality assurance program.

C. The software types which support Waste Acceptance Process Activities of high-level waste form production are specified.

D. Software and computer codes are verified and validated.

E. Management commits to regularly assess the effectiveness of the quality assurance program.

F. Peer reviews and readiness reviews are conducted on items and data significant to Waste Acceptance Process Activities of high-level waste form production in accordance with an approved documented program.

G. Provisions are established to assure that implementing technical and quality assurance procedures are consistent with quality assurance program requirements.

H. Measures are provided to assure that personnel responsible for performing quality-affecting activities in Waste Acceptance Process Activities of high-level waste form production are indoctrinated, trained, and qualified in the principles, techniques and requirements of the activities being performed.

I. The quality assurance organization reviews and documents concurrence with quality-related procedures and revisions thereto.

J. Provisions are established to control the distribution of quality assurance manuals and revisions thereto.

K. A description is provided on how management (outside of the quality assurance organization) regularly assesses the scope, status, adequacy, and compliance of the quality assurance program applicable to Waste Acceptance Process Activities of high-level waste form production to 10 CFR 50, Appendix B, and ANSI/ASME NQA-1, 1986.

L. A description of the control system for experimental or developmental work associated with Waste Acceptance Process Activities of high-level waste form production is provided and it clearly identifies how it was validated.

M. Experimental research activities are accomplished in accordance with written procedures.

N. Management monitors the performance of individuals involved in quality-affecting activities and determines the need for retraining and/or replacement.

III. Activities related to design control are acceptable if:

A. Measures are established to carry out design and design modification activities associated with Waste Acceptance Process Activities of high-level waste form production in a planned, controlled, and systematic manner.

B. Measures are established to correctly translate design or regulatory requirements into specifications, drawings, procedures and instructions.

C. Quality standards are specified in design documents, and deviations from these quality standards are controlled.

D. Organizational responsibilities are defined for preparing, reviewing, approving, verifying and validating designs, design changes and design information documents.

E. Errors and deviations in approved design and design information documents are documented, and action is taken to assure that they are promptly corrected.

F. Interface controls among organizations involved in design and design modification activities are described.

G. Procedures require that design drawings, specifications, criteria and analysis be reviewed by the quality assurance organization to assure that the documents are prepared or revised, reviewed and approved in accordance with approved procedures and quality assurance requirements.

H. Procedures shall describe the accomplishment of the design verification process through design reviews, alternate calculations or qualification testing.

I. Procedures are established to assure that verified computer codes are certified for use and that their use is specified.

J. Design and specification changes are subject to the same design or design modification controls and the same approvals that were applicable to the original design or specification.

K. Individuals or groups responsible for design or design modification verification are other than the original designer and normally other than the designer's immediate supervisor. The verifier is qualified and not directly responsible for the design.

L. For design or design modification activities which involve the use of untried or state-of-the-art testing and analysis procedures and methods or where detailed technical criteria and requirements do not exist or are being developed, a peer review is conducted in accordance with established procedures.

IV. Activities related to procurement document control are acceptable if:

A. Procedures are established that delineate the actions to be accomplished in the preparation, review, approval, and control of procurement documents associated with Waste Acceptance Process Activities of high-level waste form production.

B. Procedures are established for the review of procurement documents to determine that quality assurance requirements are correctly stated, inspectable, and controllable; and there are adequate acceptance/rejection criteria.

C. The review and approval of procurement documents are documented prior to release.

D. Organizational responsibilities are described for:

- o Procurement planning
- o Preparation, review, approval and control of procurement documents
- o Supplier selection
- o Bid evaluation
- o Review and acceptance of supplier quality assurance programs

E. Procurement documents contain or reference regulatory requirements, design bases, and other technical requirements.

V. Activities related to instructions, procedures and drawings are acceptable if:

A. Organizational responsibilities are described for assuring that activities affecting quality in Waste Acceptance Process Activities of high-level waste form production are:

- o Prescribed by documented instructions, procedures and drawings.
- o Accomplished through the implementation of these documents.

B. Instructions, procedures and drawings include quantitative and qualitative acceptance criteria.

C. Methods for complying with each of the applicable quality assurance criteria are specified in instructions, procedures and drawings.

VI. Activities related to document control are acceptable if:

A. The scope of the document control system is described, and the types of controlled documents in Waste Acceptance Process Activities of high-level waste form production are identified.

B. Procedures are established for the review, approval, issuance, and revision of documents.

C. Procedures are established to assure that documents are available at the location where the activity will be performed prior to initiating work.

D. Procedures are established to assure obsolete documents are removed and replaced in a timely manner.

E. A master list is established to identify the current revision of documents that are controlled.

F. Data or data interpretations generated outside the quality assurance program are qualified.

G. Data qualification reviews are accomplished in accordance with written procedures.

H. Review and acceptance of data as qualified is based upon an independent review by at least two qualified individuals, a peer review or conformation tests.

I. The establishment and implementation of the document control system is reviewed prior to implementation to confirm its readiness to function.

VII. Activities related to control of purchased material, equipment and services are acceptable if:

A. Organizational responsibilities and interfaces are described for the control of purchased material, equipment and services associated with Waste Acceptance Process Activities of high-level waste form production.

B. Qualified personnel evaluate a supplier's capability to provide acceptable services and products prior to the award of a contract. Quality assurance and technical personnel participate in the evaluation.

C. The results of supplier evaluations are documented.

D. Surveillance of supplier activities during the contract life is planned and accomplished in accordance with written procedures.

E. Supplier documentation requirements are specified in the contract for procurement of material, equipment or services.

F. Suppler's certificates of conformance are periodically evaluated by audits, independent inspections or tests to assure that they are valid and the results are documented.

G. Receiving inspection of supplier-furnished material, equipment and services is performed to assure that the supplied item is properly identified, satisfies predetermined inspection requirements, and the required documentation is correct and available. Acceptance requirements are described in the purchaser's quality assurance program.

VIII. Activities related to identification and control of materials, parts and components is acceptable if:

A. Procedures are established to identify and control materials, parts and components (including consumables) in Waste Acceptance Process Activities of high-level waste form production.

B. Procedures are established to assure identification of items is maintained on items or records traceable to the item.

C. Correct identification of an item is verified and documented prior to release for processing or shipment.

IX. Activities related to control of special processes are acceptable if:

A. Special processes associated with Waste Acceptance Process Activities of high-level waste form production are procedurally controlled. A listing of these special processes is provided. Special processes are generally those processes where direct inspection is impossible or disadvantageous.

B. Organizational responsibilities are described for the qualification of special processes, equipment and personnel.

C. Procedures, equipment and personnel associated with special processes are qualified in accordance with applicable codes, standards and/or specifications. Qualification records are filed and kept current.

D. Special processes are performed by qualified personnel in accordance with written instructions, and the results recorded.

X. Activities related to inspection are acceptable if:

A. An inspection practice is established to verify conformance of quality-affecting activities in Waste Acceptance Process Activities of high-level waste form production with requirements. The inspections are performed in accordance with controlled procedures.

B. Organizational inspection responsibilities are documented. Inspection personnel are independent from those performing the activity being inspected.

C. A qualification practice for inspection personnel is established and documented. Inspection personnel qualification and certification records are kept current.

D. Comprehensive inspection procedures, instructions or checklists are provided for inspection activities.

E. Provisions are established that identify mandatory inspection hold-points for witness by designated inspection personnel.

F. Inspection results are documented and evaluated and their acceptability determined by a responsible individual.

XI. Activities related to test control are acceptable if:

A. A test program to demonstrate that processes, items and activities associated with Waste Acceptance Process Activities of high-level waste form production will meet predetermined requirements is established, documented and accomplished in accordance with controlled procedures.

B. Test procedures incorporate or reference:

(1) Test requirements and acceptance limits
(2) Instructions for performing the test
(3) Test prerequisites
(4) Mandatory inspection hold-points
(5) Acceptance/rejection criteria
(6) Methods of documenting or recording test data or results
(7) Method of data analysis

C. Test results are documented, evaluated and their acceptability determined by a responsible individual or group.

XII. Activities related to control of measuring and test equipment are acceptable if:

A. The scope of the program for the control of measuring and test equipment used in Waste Acceptance Process Activities of high-level waste form production is described, and the types of equipment to be controlled are identified.

B. Organizational responsibilities are documented for establishing, implementing and assuring the continuing effectiveness of the calibration system.

C. Procedures are established for calibration, maintenance and control of measuring and test equipment.

D. Measuring and test equipment is identified and traceable to calibration test data.

E. Measuring and test equipment is labeled or otherwise identified to indicate the due date of the next calibration and to provide traceability to calibration records.

F. Measuring and test equipment is calibrated at specified intervals based on required accuracy, purpose, usage, stability, and other attributes which could affect measurement.

G. Calibration standards are traceable to nationally recognized standards. Where these standards do not exist, provisions are established to document the basis for calibration.

H. When measuring and test equipment is found out of calibration, evaluations are made and documented to determine the validity and acceptability of measurements performed since the last calibration.

I. The complete status of all items under the calibration system is documented and maintained.

XIII. Activities relating to handling, storage and shipping are acceptable if:

A. Special handling, preservation, storage, cleaning, packaging and shipping requirements are established in accordance with predetermined work and inspection instructions for Waste Acceptance Process Activities of high-level waste form production. They are accomplished by qualified individuals.

B. Procedures are prepared in accordance with design and specification requirements to preclude damage, loss or deterioration.

XIV. Activities relating to inspection, test and operating status are acceptable if:

A. Procedures are established to indicate the status of inspections and tests on individual items and activities associated with Waste Acceptance Process Activities of high-level waste form production.

B. The application and removal of status indicators is procedurally controlled.

C. The status of discrepant items and activities is documented, and the item or activity is identified to prevent inadvertent use or inappropriate processing or continuation.

XV. Activities relating to nonconforming materials, parts or components are acceptable if:

A. Procedures are established for identifying, documenting, tracking, segregating, reviewing, dispositioning, and notifying affected organizations of nonconforming items and activities (including computer codes) associated with Waste Acceptance Process Activities of high-level waste form production.

B. Organizational responsibilities relating to nonconformance control is described in writing.

C. Provisions are established identifying individuals or organizations delegated the responsibility and authority to disposition and close out nonconformances.

D. Nonconformance reports are analyzed to show quality problems and to aid in identifying root causes of nonconformances. Results are reported to senior management for action as applicable.

XVI. Activities relating to corrective action are acceptable if:

A. Conditions adverse to quality in Waste Acceptance Process Activities of high-level waste form production are evaluated in accordance with established procedures to determine the need for corrective action.

B. Corrective action is documented and initiated following a nonconformance to preclude recurrence.

C. Timely follow-up actions are conducted to verify implementation of corrective actions and to close out the corrective action documentation.

D. Significant conditions adverse to quality are documented and reported to cognizant levels of management for action to remedy the conditions and preclude repetition.

XVII. Activities relating to quality assurance records are acceptable if:

A. The scope of the records program is defined such that sufficient records are maintained to provide documentary evidence of the quality of canistered waste forms and Waste Acceptance Process Activities of high-level waste form production related to the quality of canistered waste forms.

B. Organizational responsibilities are identified and described relating to quality assurance records.

C. Records are identified and retrievable.

D. Responsibilities and requirements for record creation, transmittal, retention, and maintenance consistent with applicable codes, standards, and procurement documents are detailed in procedures.

E. Inspection and test records contain the following where applicable:

(1) A description of the type of observation.
(2) The date and results of the inspection or test.
(3) Information related to conditions adverse to quality.
(4) Inspector or data recorder identification.
(5) Evidence as to acceptability of the results.
(6) Actions take to resolve any discrepancies noted.

F. Suitable facilities for the storage of records are described and utilized.

G. Work not directly associated with the records program is prohibited within the records storage facility.

H. Smoking, eating, or drinking is prohibited throughout the records storage facility.

XVIII. Activities relating to audits are acceptable if:

A. Audits are performed to assure that procedures and activities comply with the overall quality assurance program applicable to Waste Acceptance Process Activities of high-level waste form production.

B. Audits are conducted in accordance with established procedures or checklists and conducted by trained and qualified personnel not having direct responsibilities in the area being audited.

C. Audit results are documented and then reviewed with management having responsibility in the area audited.

D. Audits are regularly scheduled on the basis of the status and the importance to safety or waste isolation of the activities being performed to assure effective quality assurance during the total life of Waste Acceptance Process Activities of high-level waste form production.

E. Audit deficiency data are analyzed, tracked and trended. Resultant reports indicating trends and quality assurance program effectiveness are provided to management for review, assessment, corrective action, and follow-up.

APPENDIX C

REFERENCE DOCUMENTS

The following list of documents has been referred to in DOE-OCRWM Specification, "Quality Assurance Requirements for High-Level Waste Form Production".

(1) Appendix B - 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants".

(2) 10 CFR Part 60, "Disposal of High Level Radioactive Waste in Geologic Repositories," Subpart G, "Quality Assurance".

(3) ANSI/ASME NQA-1, 1986, "Quality Assurance Program Requirements for Nuclear Facilities".

(4) DOE 5000.3, "Unusual Occurrence Reporting System".

(5) DOE 5700.6B, "Quality Assurance".

(6) DOE/RW-0005, "Mission Plan for the Civilian Radioactive Waste Management Program".

(7) DOE/RW-0032, "OCRWM Quality Assurance Management Policies and Requirements".

(8) DOE/RW-0043, "Program Management Systems Manual".

(9) DOE/RW-0095, "Quality Assurance Plan for High-Level Radioactive Waste Repositories (OGR/B-3)."

(10) "Guidelines for Application of Readiness Reviews to Department of Energy Activities," January 1987 Draft.

(11) NUREG 0856, "Final Technical Position on Documentation of Computer Codes for High-Level Waste Management".

(12) DOE/RW-0125, Waste Acceptance Preliminary Specification for The Defense Waste Processing Facility High-Level Waste Form (OGR/B-8).