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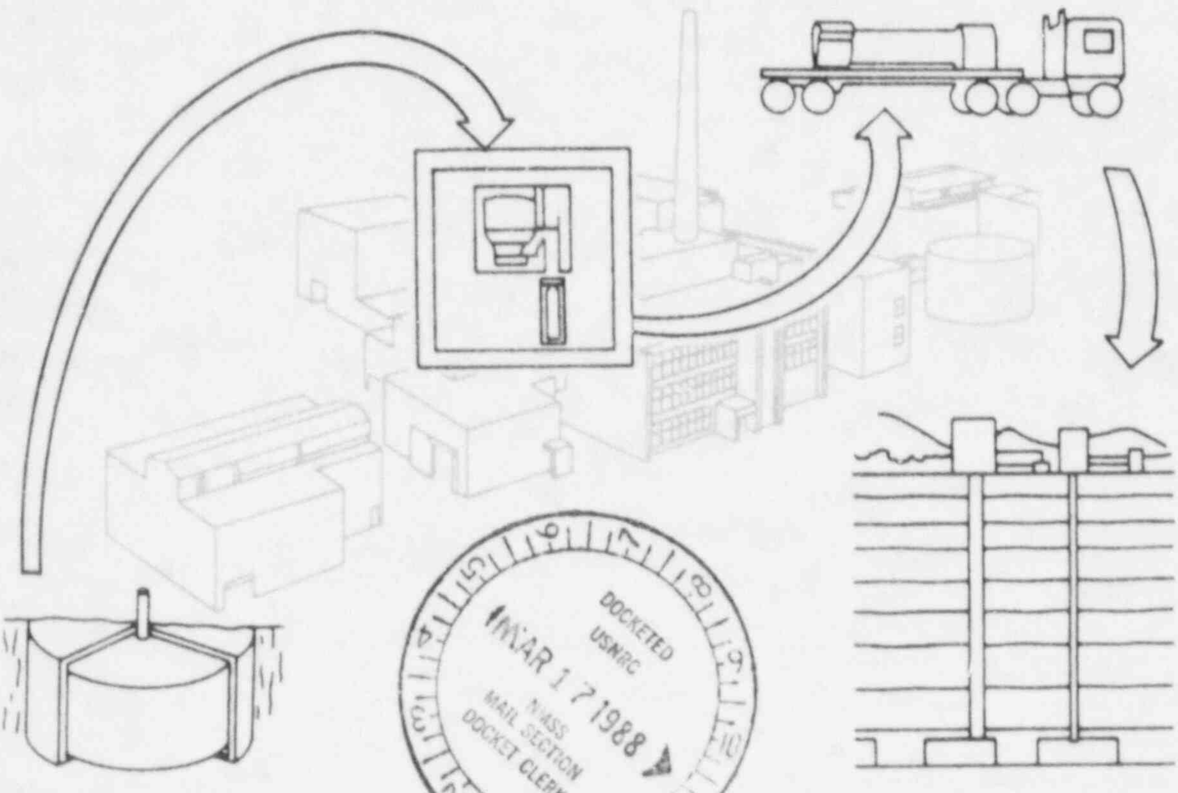
WASTE COMPLIANCE PLAN FOR THE WEST VALLEY DEMONSTRATION PROJECT HIGH-LEVEL WASTE FORM



WEST VALLEY DEMONSTRATION PROJECT

WEST VALLEY, NEW YORK

24135

WVDP-055
October 1986

WASTE COMPLIANCE PLAN

FOR THE

WEST VALLEY DEMONSTRATION PROJECT

HIGH-LEVEL WASTE FORM

KMG0297:ENG-228

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FOR THE

WEST VALLEY DEMONSTRATION PROJECT

HIGH-LEVEL WASTE FORM

INTRODUCTION

The West Valley Demonstration Project (WVDP) will solidify the liquid High-Level Waste (HLW) remaining at the former commercial nuclear fuel reprocessing plant at West Valley, New York, and will provide a qualified HLW product to the waste repository operators for disposal. Borosilicate glass is the waste form [1,2]. The current WVDP reference glass composition is listed in Table I. Reference 3 describes the current reference WVDP canistered HLW Form. Based on a recent mass balance about 520,000 kg of waste glass will be poured into stainless steel canisters.

The HLW that will be treated by the WVDP resulted from the PUREX and THOREX reprocessing methods. The current reference HLW composition based upon a liquid HLW characterization program [4-6] is shown in Appendix A. The PUREX waste is stored in Tank 8D-2, and the THOREX waste is stored in Tank 8D-4. Tanks 8D-1 and 8D-3 are spare storage tanks for the PUREX and THOREX wastes, respectively. The waste that will be immobilized in the glass will be PUREX solids, THOREX, and cesium loaded zeolite IE-96. The PUREX solids are predominately hydroxide precipitates from the neutralization of a nitric acid solution. The THOREX waste is predominately nitrates in a nitric acid solution. The cesium in the PUREX supernatant will be removed by zeolite IE-96 ion exchange material. The decontaminated supernatant will be solidified in the cement solidification system (CSS) and disposed as low-level waste. The cesium loaded zeolite will be mixed with the PUREX solids, THOREX, and glass formers and melted in the WVDP melter. The reference waste loading of the

TABLE I: COMPOSITION OF WVDP REFERENCE GLASS

Component	Amount (Wt. %)*
AgO	0.0001
Al_2O_3	1.19 - 7.15
AmO_2	0.0073
BaO	0.04 - 0.08
B_2O_3	9.33 - 10.66
CaO	0.39 - 0.93
CdO	0.0003
CeO_2	0.04 - 0.10
CmO_2	0.0001
CoO	0.0002
Cr_2O_3	0.21 - 0.48
Cs_2O	0.05 - 0.13
CuO	0.0001
Eu_2O_3	0.0014
Fe_2O_3	8.32 - 18.50
Gd_2O_3	0.0003
In_2O_3	0.0001
K_2O	3.36 - 3.84
La_2O_3	0.02 - 0.05
Li_2O	2 84 - 3.25
MgO	1.22 - 1.39
MnO_2	0.84 - 1.96
MoO_3	0.0088
NaCl	0.01 - 0.03
NaF	0.0013
Na_2O	10.25 - 11.71
Nd_2O_3	0.08 - 0.19
NiO	0.22 - 0.52

TABLE I: COMPOSITION OF WVDP REFERENCE GLASS (CONTINUED)

Component	Range (Wt. %)
NpO_2	0.01 - 0.03
P_2O_5	0.21 - 3.16
PdO	0.0062
Pm_2O_3	0.0003
Pr_6O_{11}	0.02 - 0.05
PuO_2	0.0076
Rb_2O	0.0005
RhO_2	0.01 - 0.02
RuO_2	0.05 - 0.12
SO_3	0.14 - 0.33
Sb_2O_3	0.0001
SeO_2	0.0005
SiO_2	42.08 - 48.10
Sm_2O_3	0.02 - 0.04
SnO_2	0.0006
SrO	0.02 - 0.04
Tc_2O_7	0.0021
ThO_2	1.83 - 6.56
TeO_2	0.0028
TiO_2	0.92 - 1.05
UO_2	0.37 - 0.87
Y_2O_3	0.01 - 0.03
ZnO	0.0010
ZrO_2	0.19 - 0.45
Insolubles	0.0080

* Most components are listed as a range. The amounts of minor components are not listed as a range but are listed to four decimal places to show their presence.

glass will be about 31 weight percent waste oxides . About 22 weight percent will be from the PUREX sludge and THOREX waste, and 9 weight percent will be from the zeolite. The reference radioactivity that is included in the waste is shown in Appendix A.

A flow diagram of the West Valley reference HLW vitrification process is shown in Figure 1. It is planned for the zeolite and THOREX waste to be transferred to and mixed with the PUREX solids in HLW Storage Tank 8D-2 where the PUREX waste is currently stored. The slurried waste will be transferred to the Concentrator Feed Makeup Tank (CFMUT), sampled, and concentrated. Alternatively, the waste streams will be fed individually to the CFMUT. Bulk glass formers will be added to the CFMUT; the amount will depend upon process instrumentation readings and the sample analysis results. After mixing, the waste and glass formers will be transferred to the Melter Feed Tank (MFT), and metered to the Slurry Fed Ceramic Melter (SFCM). Molten glass will overflow from the melter into a stainless steel canister by either periodic batch pouring or continuously. Following cool down, the canisters will be moved to and stored in the Chemical Process Cell of the existing reprocessing plant facility. This process equipment is currently being tested at the Component Test Stand (CTS) at West Valley; ultimately the CTS will be converted to the Vitrification Facility.

The U. S. Department of Energy is developing Waste Acceptance Preliminary Specifications for the West Valley Demonstration Project High-Level Waste Form [7] that will establish minimum requirements that WVDP HLW must meet to be compatible for disposal in a repository. Components of the waste form (glass), canister, and canistered waste form must be shown to meet these specifications. This document, the Waste Compliance Plan for the West Valley Demonstration Project High-Level Waste Form (WCP), provides the methods that the WVDP will use to show compliance with the specifications. It is based on showing compliance with the draft specifications dated October 1986. The data collected on tests performed to show compliance with the specifications before the start of radioactive waste vitrification will be reported in a Waste Qualification Report (WQR). In many instances the specifications discuss the inclusion in the WCP of information that requires the collection and analysis of data. Generally, this information is not yet available and will be

WEST VALLEY HLW PROCESSING FLOW SHEET

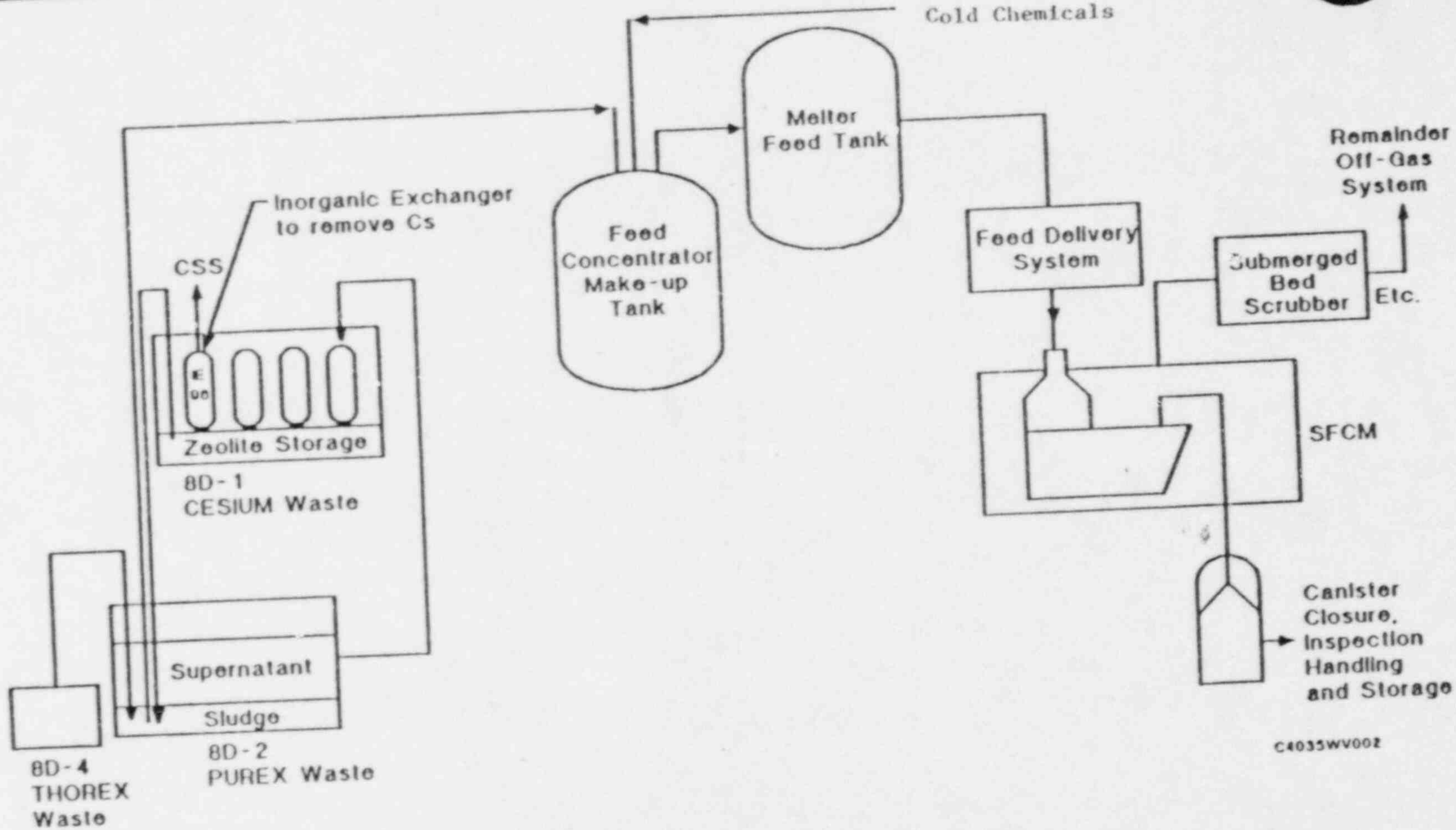

FIGURE 1

reported in the WQR. Data on radioactive waste glass, canisters, and canistered waste glass will be reported in production records. Not all procedures that will be used to generate data have been developed at this time. However, data that will be reported in the WQR and production records will be collected according to approved procedures.

Each specification is given below in bold type followed by a strategy that summarizes the activities that will be performed. The compliance section describes the details of those activities that will be performed to show that the specification will be met. Several of the specifications are not fixed. These specifications are reserved and are denoted by [R#] in the text of the specification. An explanation of the reserved items is in Appendix B.

1.0 WASTE FORM SPECIFICATIONS

1.1 Chemical Specification

The waste form for WVDP 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 used to make these projections shall be described by the producer in the Waste Form Compliance Plan (WCP).

Strategy

The WVDP will process glass with one target composition. To account for uncertainties that may be encountered during vitrification, two sets of data on WVDP glass will be generated. The first set is the glass compositional field that satisfies the Specification for Radionuclide Release Properties (see Section 1.3). The second set is the processibility (e.g., viscosity and resistivity) compositional field. The expected range of glass compositions will be within the intersection of these two sets.

Based upon prototypic, full scale tests, typical canistered glass cooling rates and times will be determined. Laboratory glasses with a nominal composition will be fabricated and heat treated based on the prototypic cooling rates. These glasses will be characterized for defining the crystalline phases that will be present.

Compliance

The WVDP will process glass with one target composition. Because there will be uncertainties associated with this composition during vitrification due to sampling and analysis, the WVDP is characterizing glasses of varying compositions (a variability study). The glass will be characterized by generating two sets of data. The first set is the glass compositional field that satisfies the Specification for Radionuclide Release Properties the tests being performed to generate this field are discussed in Section 1.3. The second set is the processibility compositional field. This set constrains the glass composition by the process equipment and includes molten glass properties such as viscosity and resistivity. This concept is illustrated in Figure 2. Methods being developed to analyze the tested glass compositions are for inductively coupled plasma spectroscopy, direct current plasma spectroscopy, and atomic absorption spectrphotometry; these will be supplemented with other techniques if needed. The compositional

STRATEGY FOR ACHIEVING A DURABLE AND PROCESSIBLE GLASS

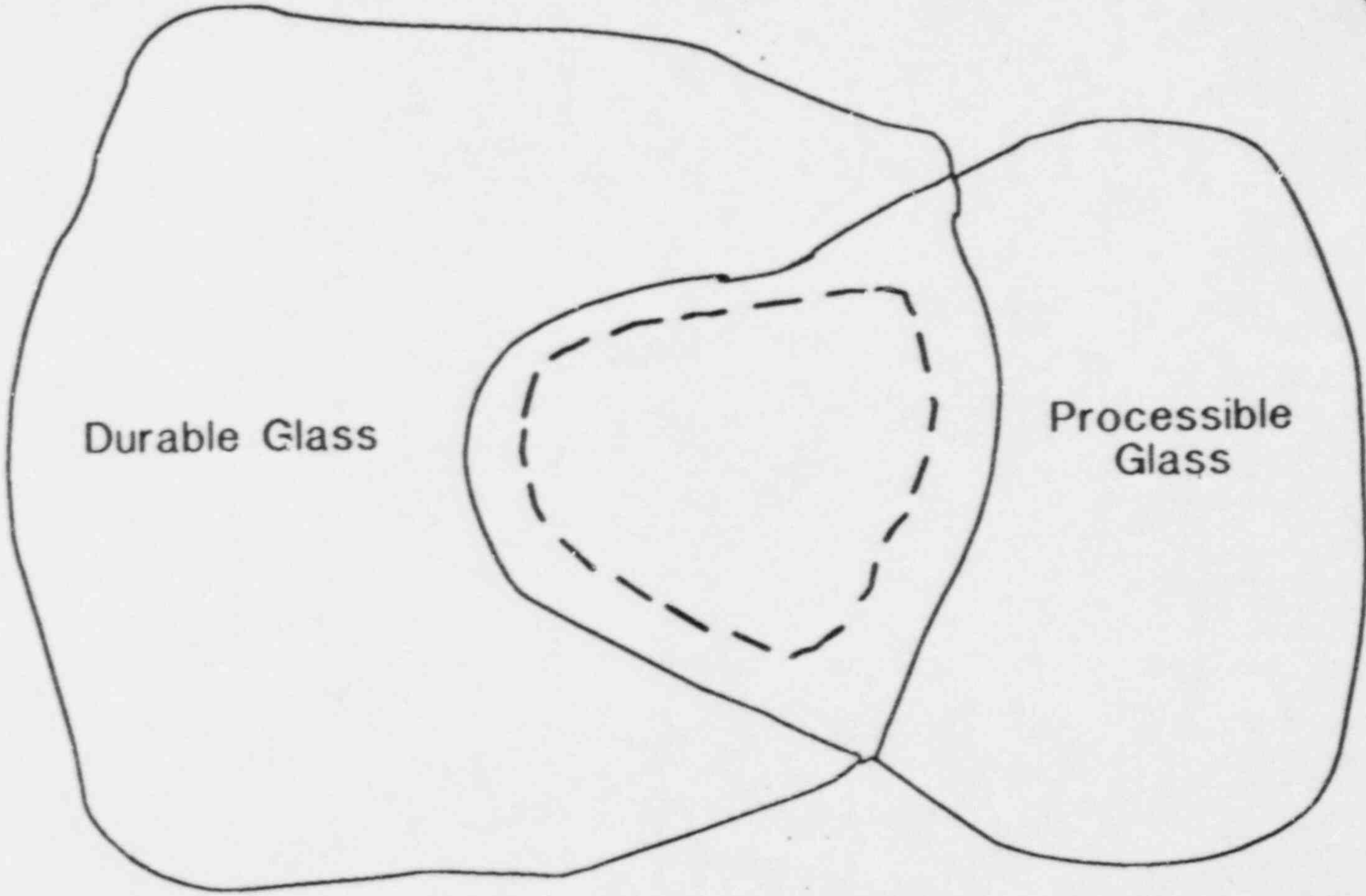

FIGURE 2

fields will be based upon immobilizing the WVDP HLW c' emical composition shown in Appendix A. Glass compositions that meet the Specification for Radionuclide Release Properties / d are processible will be reported in the WQR.

Estimates of the crystalline phases in the pr' uct will be based on full scale nonradioactive tests that will be completed to define typical cooling rates that will be experienced in the actual canistered glass. The thermal history of the glass in a typical canister varies as a function of position in the filling canister. The zone of highest crystallization exists near the center of the cross section of the canister half way up the filled height. This will represent the extreme condition for crystallization. Near the walls of the canister the glass is typically a quenched material that is essentially wholly vitreous.

Glass samples will be prepared in the laboratory that have a nominal composition. These samples will have radioactive thorium and uranium at their full levels. The balance of the TRU constituents will be simulated with thorium, uranium, rare earths and/or other appropriate elements. Insoluble waste constituents such as ruthenium, palladium, and rhodium will also be present at reference concentrations since they can serve as nucleating sites for crystals. Based upon the temperature history measured in the full scale tests, four laboratory specimens of a nominal composition will be heat treated in a programmed cool down rate corresponding approximately to the following canister locations:

- 1 cm from the canister wall
- 4 cm from the canister wall
- 10 cm from the canister wall
- canister centerline

All these temperature histories will be taken near the mid fill height of the test canister.

These laboratory heat treated glass specimens will be characterized for crystalline phases present in quantities exceeding five volume percent. The total volumetric quantity of nonvitreous material which is found in the bulk of the glass specimen away from the free surface and the crucible wall will be reported in the WQR.

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 [sic] accuracy and the basis for the estmate [sic] of the precision shall be reported in the WCP.

Strategy

Either a process model will be developed during cold testing to relate the melter feed composition to the glass composition during hot operations or the waste glass will be sampled. The precision and accuracy will be based upon the results of nonradioactive testing at the CTS.

Compliance

Two methods are being considered for complying with this specification: sampling the feed and relating its composition to that of the glass by way of a process mass balance model or sampling the radioactive waste glass. These are discussed below. The decision on which method to use will be based upon the overall achievable precision and accuracy, capability to develop and

implement the method by the beginning of waste vitrification, ease of use during system operation, and overall cost. The expected precision and accuracy of the method selected will be reported in the WQR. This will be based on the sampling tests performed during nonradioactive testing (e.g., repeatability of sampling method, relating the sample to the bulk material being sampled) and on the analytical methods used.

Compliance Method #1

The waste form chemical composition will be based upon a simplified process mass balance model that will predict the composition of the glass in the canister. The WVDP will report the waste glass composition by sampling and analysis of the waste slurry, and by adding known amounts of nonradioactive chemicals to the waste. The mass balance will assume that either the constituents go into the canister or to the process off gas.

During full scale nonradioactive testing in the actual waste vitrification equipment, frequent samples of the slurry feed, draining glass, and canistered glass will be taken and analyzed. This will form the data base that assures that the waste glass is as predicted by the model. An example of a process model for waste vitrification and how it can be used is discussed in Reference 8.

The production records will include:

- Chemical analysis of the waste based on the sample from the concentrator that corresponds to the glass in the particular canister.
- Concentrator tank level at the time of sampling
- Chemicals added to the concentrator to make the slurry melter feed.
- Melter plenum temperature and average slurry feed rate.

Compliance Method #2

During full scale nonradioactive testing in the actual waste vitrification equipment, frequent samples of the draining glass and canistered glass will be taken, analyzed, and reported. Samples of the canistered glass will be removed from the top of the glass and compared with the results from the bulk of the casting and with the drain glass samples. It will be demonstrated that the shards and glass "hair" that can be removed from the canister opening will be representative of the bulk glass composition. It will further be determined how frequently the canisters must be sampled to demonstrate that the composition of the waste form falls within the acceptance region when process variations and upsets are considered.

During waste vitrification the glass will be sampled after the canistered waste form is removed from the turntable. The frequency that samples will be removed will be determined during the cold testing at the CTS; it will be based on the sampling variability observed. A glass shard or glass "hair" will be removed from the top of the canistered glass, transferred to the analytical laboratory, and chemically analyzed for composition. The production records will include the chemical analysis results of the glass shard or "hair" that was analyzed.

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 [R1] of the total radioactive inventory in curies (in the aggregate or in the canistered waste form, as applicable) at any time up to 1100 years after production.

1.2.1 Radionuclide Inventory Projections

The producer shall provide in the WQR estimates of the

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

Strategy

The projected total radionuclide inventory estimates will be based upon an ongoing waste characterization program for WVDP HLW. The projected estimated inventory in a canister will be based upon filling canisters nominally 85 percent full.

Compliance

The estimated radionuclide inventory projections will be based on a liquid high-level waste characterization program being performed at West Valley.[4-6] Computer simulations using ORIGEN2 [9] runs have been made using available data for each of the separate irradiated fuel campaigns. Plutonium and uranium recovery data were used to separate the "waste" from the "product", and processing dates were used to input decay times. Summation of all the campaigns then yielded total waste tank contents. Comparison of the ORIGEN2 output with other data, e.g., analytical, resulted in some adjustments and enabled uncertainties to be estimated.

The estimated total radionuclide inventory projection expected to be shipped from the WVDP and the estimated inventory in the canister will be reported in the WQR. These estimates will be calculated by a radionuclide balance which models the West Valley vitrification

process using the decontamination factors for each nuclide and for each major component in the vitrification process. The inventory estimated from the liquid HLW characterization program will be used as an input. Experimentally measured DF data will be used where available.

The average expected inventory in a canister will be based upon a canister 85 percent full (see Section 3.5) and using the average expected inventory. The lower bound will be based upon a canister 80 percent full and using the lower range for the total expected inventory in the waste. The upper bound will be based upon a canister 90 percent full and using the upper range for the total expected inventory.

To decay the radionuclide inventory to the required time periods, integrated radioactivity of each nuclide will be used as input to the ORIGEN2 computer code. Decay of radionuclides and buildup of daughter nuclides in the canister will be calculated.

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.**

Strategy

Either the radionuclide inventory in the feed will be related to the inventory of the glass in the canister via the process model or the inventory in glass samples will be measured. Radionuclide inventory in the feed or glass sample will be obtained by measuring the inventory of key radionuclides and relating these values to other necessary values through the use of scaling factors derived from the waste characterization program.

Compliance

The same approach used to provide chemical composition during waste vitrification will be used to provide radionuclide inventory in a canistered waste form, i.e., one of two methods will be used. Either a glass shard or "hair" will be removed from the top of the canistered glass and analyzed for the radionuclide inventory, or a sample of the waste feed will be analyzed for the radionuclide inventory and related to the inventory in the glass by a process model. This is discussed in Section 1.1.2. The expected precision and accuracy of the estimates made during vitrification is not available at this time; they will be reported in the WQR. They will have the same basis as those for chemical composition.

During vitrification, the sample will be analyzed for Sr-90, U-235, Pu-238, Pu-239/240, and gamma emitting isotopes. Values for the remaining radionuclides will be obtained by using scaling factors developed during the West Valley HLW Characterization Program.[4-6] Scaling factors for those radionuclides that will not be directly measured but have half-lives greater than 10 years and are expected to be in concentrations greater than 0.05 percent of the radioactivity inventory will be developed from a waste sample removed after sludge homogenization. This will ensure that a representative sample is used to develop the scaling factors. The weight of glass in each canister will be measured and will be included in the production records for each canister. From this, and the specific activity in the sample, the amount of each radionuclide present in each canister will be estimated and reported in production records. ORIGEN2 calculations will be used to calculate the radionuclide content of each canister at time of shipment and to ensure that all radionuclides with half lives greater than ten years in concentrations greater than 0.05 percent of the total radioactive inventory at any time up to 1,100 years after production will be reported.

1.3 Specification for Radionuclide Release Properties

The producer shall document that the radionuclide release properties of the waste form have been controlled so that the borosilicate waste glass can meet the limits specified in repository-specified tests TBD* [R2]. Before shipment the producer shall document that the waste forms at time of production are in compliance with the radionuclide release specification for the receiving repository. The producer shall describe the intended method for demonstrating compliance with each repository-site-specific requirement in the WCP. Supporting technical documentation for the selected method of compliance shall be included in the WQR.

Strategy

The WVDP will characterize the glass under static and flowing conditions and work with the repository projects to include West Valley glass in their test programs.

Compliance

Because this specification is incomplete, the WVDP cannot perform tests that specifically meet the requirements. However, to meet the intent of this specification the WVDP is performing tests to characterize its glass for radionuclide release properties. These are discussed below.

The WVDP is performing Static Leach Tests (e.g., MCC-1 [10]), Interactive Powder Leach Tests, and Partial Exchange Interactive Flow Tests[(11-12)] on the sets of glasses discussed below. The summaries of the static and flow test methods are in Appendix C. The Interactive Powder Leach Test is based on the MCC-3 test method; the whole procedure is included in Appendix C for information. These tests characterize the behavior of the glass under static and flowing conditions. The test temperature is 90°C. Generally, the test durations are 28 days for the static test, seven days for the Interactive Powder Leach Test, and as

* TBD - to be determined.

indicated in Appendix C for the Partial Exchange Interactive Flow Test. The replacement interval for the Flow Test will be selected to simulate the flow expected in a repository after discussions with representatives of the repository projects. Each test performed on an acceptable glass will be in triplicate. The pH of the leachant will be provided. The elements listed in Table II will be analyzed in the leachant by direct current plasma spectroscopy, inductively couple plasma spectroscopy, atomic absorption spectrophotometry or other techniques necessary to analyze the elements. Acceptable test results will be when the mean boron release rates or concentrations in the leachant are:

- o Static Leach Test: 1.5 $g/m^2 \cdot d$ release rate
- o Interactive Powder Leach Test: 1 $g/m^2 \cdot d$ release rate
- o Partial Exchange Interactive Flow Test: 40,000 mg/l concentration

The sources of the test glasses are:

- o ATM-10, an Approved Test Material fabricated by the Materials Characterization Center (MCC) incorporating elements in WVDP HLW; it is doped with Am, Np, Pu, Tc, Th, and U. See Table III for the target composition.
- o A small scale melter; the glass is doped with full levels of Th and U. Various compositions around the nominal composition will be melted.
- o The WVDP Component Test Stand (CTS) melter; appropriate elements will be used as substitutes for the radioactive elements. Various compositions will be melted.
- o Lab scale crucibles; some glass will be doped with Th and U and some will have appropriate elements substituting for the actinides. Various compositions will be melted.

TABLE II

Elements that will be analyzed in the leachant after leach testing WVDP glasses.

Am*
Al
B
Ca
Cs
Fe
K
Na
Np*
P
Pu*
Si
Sr
Tc*
Th*
U*

* Analysis will be performed for these elements only if they are included in the glass composition.

TABLE III

Target Composition for ATM-10 Glass

Oxide	Target Wt. %
Al_2O_3	6.50
AmO_2	0.0068
B_2O_3	9.26
BaO	0.05
CaO	0.56
CeO_2	0.07
Cr_2O_3	0.29
Cs_2O	0.07
Fe_2O_3	11.31
K_2O	3.33
La_2O_3	0.03
Li_2O	2.82
MgO	1.21
MnO_2	1.22
Na_2O	10.17
Nd_2O_3	0.17
NiO	0.32
NpO_2	0.0208
P_2O_5	2.33
PuO_2	0.0085
RhO_2	0.01
RuO_2	0.07
SO_3	0.27
SiO_2	44.90
SrO	0.03
Tc_2O_7	0.0030
ThO_2	3.34
TiO_2	0.91
UO_2	0.52
Y_2O_3	0.02
ZrO_2	0.27
TOTAL	100.09
Fe^{+2}/Fe^{+3}	0.10

ATM-10 is a homogenous glass and will be used to obtain durability information especially on those radioactive elements that are used as dopants. The static and pulsed flow tests in deionized water (DIW) will be performed using ATM-10. The MCC will also make ATM-10 available to the repository projects for their testing programs. For example, the Nevada Nuclear Waste Storage Investigation Project may use the glass in static and powder type tests and in an unsaturated test (14), and the Basalt Waste Isolation Project may use it in its powdered glass and basalt test. (Likewise, the WVDP will make available the glass doped with the Th and U, and glass melted by the CTS melter and poured into reference canisters).

Based upon the target composition discussed in Sec..... ..1.1, glasses doped with Th and U of varying compositions will be melted and tested to provide a phase field in which the glass will be characterized. The Interactive Powder Test and Pulsed Flow Test will be performed in DIW. The compositional boundary for the elements listed in Table IV will be investigated singly, i.e., one element will be raised or lowered at a time. This will provide the basis for control of the release properties by composition.

A nominal glass composition with Th and U will be remelted at various redox states and characterized by the above tests to assess the effect of glass redox state on durability. The value of the redox state of the glass is a result of processing conditions. The redox state that processes optimally will be identified. Glasses of that redox state and of redox states on either side will be tested as described above in DIW. This will provide the effect of changes in redox state that could be generated during waste vitrification.

TABLE IV

Elements that will be varied to define the durability boundary

Element	High	Low
Si	X	X
Th	X	X
Fe	X	
P	X	X
B	X	
Na	X	
Cr	X	
Al	X	X
U	X	X

During cold testing the cooling rate of the glass in the canister will be monitored such that the test specimens fabricated in the laboratory can be heat treated to simulate the canistered glass (See Section 1.1.1). After monitoring the glass temperatures in a series of canisters a reference cooling heat treatment will be developed, it will simulate the heat treatment of the glass at 4cm from the surface. Specimens of a nominal glass composition containing Th and U will then be subjected to this heat treatment and characterized by the above durability tests. This will provide an assessment of the effect of the cooling rate on durability.

In addition to deionized water, ground waters expected to be found in repositories that will use the waste glass as a barrier to radionuclide release, e.g., the tuff repository and salt repository, will be used in the above tests. The tests will be performed using a glass of nominal composition. This testing will provide a correlation between different leachates.

To monitor the potential bias of the results within an individual laboratory, several facilities will be used to perform these tests. The Vitreous State Laboratory (VSL) of the Catholic University of America is testing the glasses of various chemical compositions and redox states, the heat treated glasses, and glass in repository ground waters. Pacific Northwest Laboratory (PNL) will overlap the testing of selected chemical compositions with the Interactive Powder Leach Test. The Materials Characterization Center will test ATM-10 and a glass of similar composition doped with Th and U. As a courtesy SRL will be performing static tests on WVDP glasses as part of their testing program. The WVDP will continue discussions with the repository projects about the use of WVDP glasses in their testing programs.

To assist in correlating the WVDP data with other glass data, the results of this testing will be compared to models on glass durability. This will include models developed at VSL [15],

Savannah River Laboratory (SRL)[16], and the Hahn Meitner Institute (HMI)[17]. Generally these models explain the long term behavior of the glass by using thermodynamic and kinetic approaches. The VSL model relates the test results to behavior in the repository by comparing the experimental and repository leachate contact time and the experimental and repository glass surface area to leachate volume ratio. The SRL model correlates the free energy of formation of the glass (which is related to its composition) to MCC-1 leach rates of Si. HMI uses the PHREEQE computer code, a geochemical modeling program, which follows a reaction path for the dissolution reaction; it considers hydrolysis and complexing of ions in solution and precipitation of secondary minerals.

The test results will be reported in the WQR. The results of each test performed will be reported with a standard deviation from leachant analysis and will include the leach rates of the elements listed in Table II in units of gram per meter^2 per day (g/m^2d); pH will also be reported. If any significant difference between laboratories is noticed, it will be discussed to identify the cause for the difference. Appropriate re-evaluation will be performed. Compositional limits that will provide an acceptable glass will be reported. The effect of glass redox state, canister cooling, and repository ground waters on the durability of the nominal glass composition will be discussed. The test results will be applied to the models on glass durability to provide a basis for predicting the behavior of the glass after disposal in a repository.

1.4 Specification for Chemical and Phase Stability

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

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

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

The requested data, analysis, and appropriate technical support shall be provided in the WQR. The method used to produce these data shall be described in the WCP.
At the time of shipment, the producer shall certify that the maximum waste form temperature is at least 100°C below the transition temperature of 1.4 (a) above. In addition, the producer shall certify that after the initial 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 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.

Strategy

The glass transition temperature will be measured on WVDP test glass. The time-temperature transformation behavior of the glass will be developed over the applicable time and temperature range. Thermal analysis calculations will be performed to show that the temperature limits during storage and at the time of shipment are not exceeded.

The storage facility will be designed to keep the glass below the glass transition temperature.

Compliance

a) Glass Transition Temperature

The glass transition temperature is that temperature reached on cooling when a super cooled liquid becomes a glass. More specifically, it is a marked change in atomic mobility as a function of temperature. Typically, the glass transition occurs over a short temperature range of about 5°C, below which atomic mobility is too slow to allow secondary phase formation, and above which the glass becomes more like a liquid (atomic mobility is accelerated). Nucleation and growth of second phases are possible up to the liquidus temperature (the temperature at which the material essentially finishes melting on heating) of the system, beyond which these phases redissolve.

This change in atomic mobility, the glass transition temperature, is normally detected using a thermal expansion measurement by dilatometry and/or differential scanning calorimetry.

In case of detection by thermal expansion , as a glass sample is heated, a sharp increase in thermal expansion is noted at the glass transition temperature range. The glass transition temperature is determined by the intersection of extrapolations of the lower expansion response and the higher expansion response.

In the case of differential scanning calorimetry, an endothermic peak is detected at the glass transition temperature range, and the glass transition temperature is defined as the onset of this endothermic response.

In the WQR the WVDP will provide the glass transition temperature and test heating rate for nominal WVDP test glass that includes uranium and thorium. These data will be determined using both of the two techniques cited above: differential scanning calorimetry and dilatometry.

b) Time-Temperature-Transformation Response

As discussed above for the glass transition temperature, atomic mobility can permit nucleation and growth of secondary phases. Defining this behavior is facilitated through the use of a time-temperature-transformation diagram.

The time-temperature-transformation diagram is a graphical representation of isothermal heat treatments of glass samples for specific lengths of time.

The WVDP will produce a time-temperature transformation (TTT) diagram for a nominal glass composition that contains Th and U. Typical center line and surface cooling curves from monitored canister cooling tests will be overlayed on this diagram. The TTT behavior of the glass will be determined between the center line and exterior surface curves. Phases resulting from the heat treatments will be identified for type and volume percent abundance by standard analytical techniques (e.g., optical microscopy image analyses, x-ray diffraction, scanning transmission electron microscopy). Specimens within the cooling curve region will be tested in deionized water according to the Interactive Powder Leach Test and Pulsed Flow Test methods (see Section 1.3).

Additionally, samples from canisters cast during nonradioactive testing will be extracted and compared statistically through like analyses to the time-temperature-transformation results.

Following initial cool down of the canister, the canister storage temperature will not exceed the glass transition

temperature (see below). Therefore, the TTT diagram will be relevant only during waste form production, and will forecast the type and extent of secondary phases which may exist in the waste form.

The temperatures used to develope the TTT curve will be between the glass transition temperature and the liquidus temperature. The time length of heat treatments will be between 0.5 hours and as long as canister cooling data dictates for reaching the glass transition temperature.

The time-temperature-transformation diagram, analysis, comparison to actual cold test canister samples, and corresponding release rate characteristics along the canister cooling curve will be provided in the WQR.

Canistered Waste Form Storage and Shipment

The maximum glass temperature at time of shipment (2001[18]) will be shown to be at least 100°C below the glass transition temperature by considering the West Valley canister geometry (see Figure 3), with a radionuclide inventory loading representing an upper activity bounded canister (see Section 1.2), and assuming that the surrounding air is 25°C and that the temperature drop across the convective air film is 5°C. The heat generation rate from the nuclides will be calculated by ORIGEN2. The heat source will then be an input in the thermal analysis program HEATING5.[19] Additional inputs to this program are density, heat capacity, and thermal conductivity. Standard canister material data and measurements on WVDP test glass will be used for these.

The West Valley storage facility is being designed to maintain the maximum glass temperature below the glass transition temperature. The current reference flow path and storage of the canistered waste forms after glass pouring is discussed below.

WEST VALLEY CANISTER

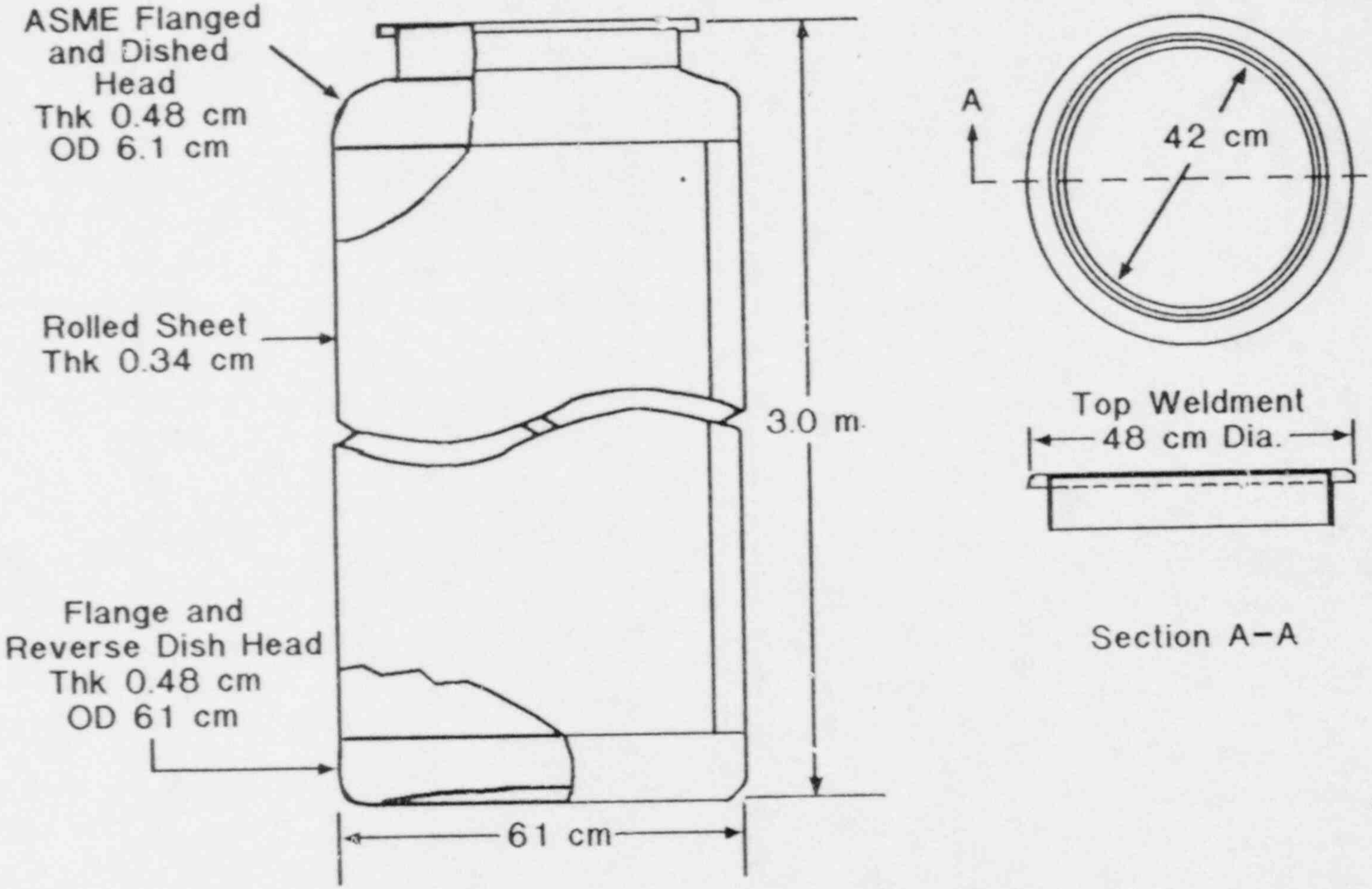

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FIGURE 3

The canister turntable will contain a maximum of four canisters and rotate through four positions. After a canister is filled it will remain in the turntable for a nominal time of 72 hours. During this time period the cooling will be accomplished via the turntable cooling jacket to lower the turntable interior temperature. After 72 hours the full canister will be removed from the turntable and placed in an open air cooling rack located in the Vitrification Cell.

After the canister has cooled to the cell ambient temperature a water-tight cap may be placed on the canister opening and the canister may be decontaminated. After decontamination canisters will be loaded into the transport car and moved out of the Vitrification Cell. They will travel through the transfer tunnel and into the Chemical Process Cell (CPC) where they will be stored. The canisters will be stored in open air racks, stacked two high in the CPC.

Cooling will be provided by three 50 percent cell coolers, each having a capability of 70,000 watts (240,000 BTU/hr). This is based on conservatively assuming that 400 canisters will be stored each with 350 watts. (This heat generation rate is more than that expected in the total HLW). One cell cooler will be held in stand-by for redundancy. The cooling to each cell cooler will be through existing 7.6 cm (3-in) closed loop transport systems. Fans within the cell coolers will move air over the coils in the cell. Operating procedures will require that during waste storage the temperature in the CPC will be monitored. The cell temperature will be related to the canistered waste form centerline temperature.

Ventilation flow to the cell is thru the Equipment Decontamination Room (EDR) to the CPC and is ducted out of the CPC to the main plant HVAC system. Nominal CPC pressure is 2.3 cm (0.92 inches) water differential. HVAC flow thru the cell is 170,000 to 230,000 litres/min. (6,000 - 8,000 ft^3/min) and is protected from backflow and contamination by a HEPA filtration system.

The CPC cell has windows on two sides of the cell, and TV cameras with monitors will be available.

If the WVDP is responsible for transporting HLW, the transportation cask that the WVDP will use to ship the waste off-site will undergo thermal analysis to show that the maximum activity loaded canister stays below the glass transition temperature during normal conditions of transportation as given in 10 CFR 71.71. The specific method that will be used to perform this analysis will be selected by the cask designer and submitted to the WVDP for approval.

2.0 CANISTER SPECIFICATIONS

2.1 Material Specification

The waste form canister and any secondary canisters to be 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.

Strategy

The canister material composition is provided in Table V. Certified materials will be used for canister fabrication.

Compliance

West Valley plans to fabricate its canisters from austenitic stainless steel ASTM A240 and A479 UNS Designation S30400. The composition of this alloy is shown in Table V. The composition of the weld filler metal, ER308L, that is expected to be used during canister fabrication is shown in Table VI. (If the composition of the weld filler metal changes it will be reported in the WQR.) The composition of the closure weld filler metal will be provided when the closure method is selected as discussed in Section 2.2.

TABLE V: CHEMICAL COMPOSITION REQUIREMENTS FOR TYPE 304 STAINLESS STEEL (S30400)*

ELEMENT	PERCENT
C	0.08
Mn	2.00
P	0.045
S	0.030
Si	1.00
Cr	18.00-20.00
Ni	8.00-10.50
N	0.10
Fe	Bal

* Maximum values unless range is indicated.

TABLE VI: CHEMICAL COMPOSITION REQUIREMENT OF ER308L*

ELEMENT	PERCENT
C	0.03
Cr	19.5-22.0
Ni	9.0-11.0
Mo	0.75
Mn	1.0-2.5
Si	0.30-0.65
P	0.03
S	0.03
Cu	0.75
Fe	Bal

* Single values shown are maximum. Other elements should not be present in excess of 0.50 percent.

Procurement and fabrication documents will require that the fabricator use certified materials and provide certified material test reports on the heats from which the canister parts were cast. Part of canister inspection at the WVDP will be verification that these certifications are included with each canister shipped. Canistered waste form production records will include the certified material test reports for the canister parts and the receipt inspection report.

2.2 Fabrication and Closure Specification

The canister fabrication methods, as well as those for any secondary canisters applied by the producer, shall be identified in the WCP and documented in the WQR. The outermost closure shall be leak tight in accordance with the definition of "leak tightness" in ANSI 14.5-1977, "American National Standard for Leakage Testing 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.

Strategy

The canister will be fabricated from sheet, bar, a dished head, and a reverse dished head. A final closure method will be selected before transport to the repository.

Compliance

The reference West Valley canister design is shown in Figure 3. WVDP plans to have its canister fabricated by cold rolling steel sheet with a minimum thickness of 0.34 cm to form the canister wall. The canister bottom will be a flange and reverse dished head; the top will be an ASME flanged and dished head. The top and bottom thicknesses are shown to be 0.48 cm. The lifting flange is planned

to be formed by cold rolling square bar. If additional material is required on a part such that the canister can be handled safely (e.g., if a stress analysis indicates that the drop test specification cannot be met), then the thickness will be increased. Fabrication welding is planned to be by gas tungsten arc welding. All welds will be ground and inspected by dye penetrant according to Section V of the ASME Boiler and Pressure Vessel Code* and meet the criteria of Section VIII. Certifications that the welds were made and inspected as specified will be required from the fabricator. Canister inspection will verify that these certifications are included. After fabrication the canisters will be leak tested. The WVDP will perform inspection and data reviews as part of the fabrication effort to ensure that the canisters comply with design requirements. The results of weld inspections and leak testing of canisters used during cold testing will be provided in the WQR; the same results for canisters used during waste vitrification will be provided in production records.

Closure weld development and qualification (i.e., leak testing) will be performed on nonradioactive canisters. Tests will be performed to develope the weld parameters that will result in a leak tight weld. Those parameters that will produce a leak tight weld will be recorded and repeated on the canisters containing the waste glass. Welders that are currently being considered for WVDP canister closure are discussed in Appendix D for information. The selection of the final closure process will be made prior to shipout to the repository.

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* Note that applicable sections of the ASME Boiler and Pressure Vessel Code will be referenced for welding and nondestructive evaluation, but the canister will not be classified as a code vessel.

2.3 Identification and Labeling Specification

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 the 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.

Strategy

The identification code for each canister will be of the form WVXXX. This code will be placed on the side and top shoulder of the canister with lettering as shown in Figure 4.

Compliance

Each West Valley canister will have a unique identification code of the form WVXXX where X is a digit. This identification code will appear on the production records that describes the canistered waste. The format for the production records will be included in the WQR.

This identification code will be on two places on the canister. One will be on the top shoulder of the canister such that the code can be seen from the vertical direction; the other will be on the side of the canister 152 cm from the bottom as shown in Figure 4. The characters for these labels will be at least 3.25 cm (92 points) tall and will be modified block. It is planned that these characters will be stamped inversely on a piece of 304 stainless steel sheet and seal welded all the way around onto the canister during fabrication. Alternatively the labels may be etched into the canister wall to preclude "hang up" or "tear off" of the label during handling. During nonradioactive testing at the CTS reference canisters will be filled at various pour rates. If glass pouring and subsequent handling effects the attachment or legibility of the label, it will be discussed in the WQR. The labeling method will be reported in the WQR.

WEST VALLEY HLW CANISTER LABELING

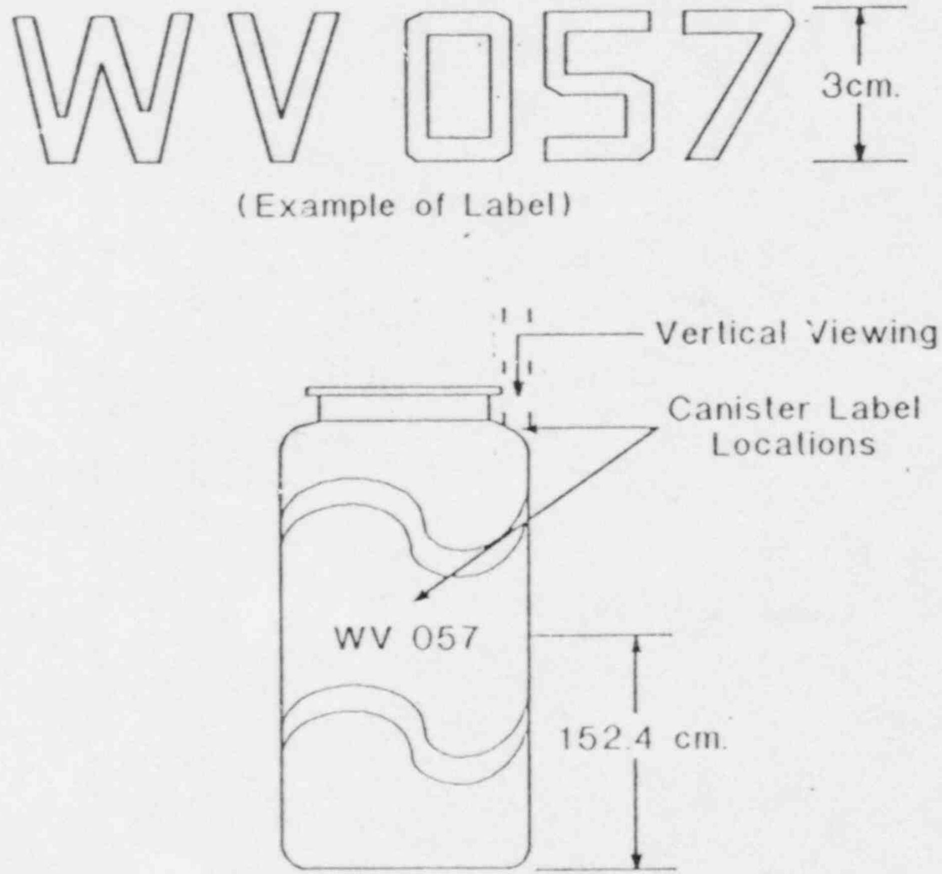

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Figure 4

The identification code that will be assigned to a canister or batch of canisters will be provided to the fabricator by the WVDP. Canister receipt inspection will include verifying that both labels on a canister are the same and that the identification number is unique i.e., not on a previous canister. After this inspection is complete, it will be noted on the production records.

After waste vitrification and canistered waste form storage, the canistered waste form labels will be visually inspected via a television camera or shield window before placement in the transportation cask to ensure that the labels are still attached and legible. An assessment will be made of the ability of the label to remain attached and legible through the normal conditions of transport and handling at the repository facility until the canistered waste form is placed in the repository container. The results of this inspection will be included on the production records. This will ensure that the service life of the label is long enough for placement in the repository container.

3.0 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.

Strategy

The vitrification process will evaporate free liquid in the feed. The canisters will be inspected prior to entry into the vitrification facility to ensure they contain no drainable liquid. The temporary closure system exposed to the canister decontamination system will be tested to show that it will be water ti, t.

Compliance

The vitrification process will take place at about 1150°C and 1 atm, and the liquid in the waste feed will be evaporated from the glass. The thermal conditions of Specification 1.4 (a) define the temperature limit below which the glass is phase stable; therefore, no free liquid will be generated by the glass up to that limit.

The canisters will be inspected to ensure that they contain no drainable liquid prior to entry into the vitrification cell. Canister decontamination may involve the use of an aqueous solution (see Appendix F). Because the final closure will not be made until before shipout, a temporary seal will be required to prevent water infiltration if the canister is decontaminated before final closure. One of the design requirements for the temporary seal system will be to provide a water tight seal for the pressure expected to be exerted by the canister decontamination system. Once a sealing method and operating parameters have been developed, canisters containing nonradioactive glass will be sealed and submitted to the decontamination process. These canisters will be inspected to verify that free liquid cannot be drained. The test canisters will be opened and tipped at an angle of at least 0.79 radians (45°) to the horizontal with the opening down. The temporary closure will be considered sufficient if no liquid is observed draining from at least three consecutively tested canisters. The results of these tests will be reported in the WQR.

During storage the canistered waste forms will be warmer than the storage cell ambient air, because the canistered waste forms are the heat source. Therefore there will not be any generation of free liquid by condensation in or on the canisters.

3.2 Gas Specification

After closure the canistered waste form shall not contain free gases, 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.

Strategy

Glass pouring and permanent closure of the canister will be in an air atmosphere. The technical literature has been reviewed and it shows that an insignificant amount of gas would be generated at the glass transition temperature. Based upon the activity in the waste the amount of radiogenic gases that could be generated will be calculated.

Compliance

The glass will pour into the canister in an air environment. Storage and final closure is planned to be in air. Therefore, the void spaces will contain air. Closure is expected to be at atmospheric pressure at about 25°C. When the final closure is performed, the cell temperature and pressure will be recorded on the production records.

Data published in the open technical literature has been compiled to provide estimates of the quantities and compositions of gases that could vaporize in the glass at about the glass transition temperature. The results of this literature review are in Appendix E and show that no significant amount of gas will accumulate inside the canister by this process.

The amount of gaseous products produced from the decay chains of Th-232, U-234, U-235, and U-238 in a canister filled with WVDP HLW glass, radon and helium, will be calculated. A canister with the upper bound radionuclide inventory (see Section 1.2.1) will be the basis for this calculation. These results will be reported in the WQR.

3.3 Specification for Explosiveness, Pyrophoricity, and Combustibility

After closure the canistered waste form shall not contain explosive, pyrophoric, and combustible materials. The producer shall describe in the WCP those administrative controls and other factors that prevent the introduction of explosive, pyrophoric, or combustible materials into canistered waste 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 the temperatures up to the transition temperature of Specification 1.4(a).

Strategy

Borosilicate glass is not any of the above types of materials. Prior to entry into the Vitrification Facility, the canisters will be inspected to ensure they do not contain any of these materials.

Compliance

Borosilicate glass, the WVDP HLW form, is oxidized and is not explosive, pyrophoric, or combustible. It is phase stable up to the glass transition temperature and will not change into these types of materials. Prior to entry into the Vitrification Facility cell, the canisters will be visually inspected to ensure that they do not contain any of the above types of materials. These materials will be prohibited in the Vitrification Facility for site safety reasons, also. Verification that this inspection took place will be recorded on the production records for the canister. The reference flow path

of the canister in the Vitrification Cell is presented conceptually in Section 1.4. The WQR will present a detailed canister flow path in the Vitrification Cell to interim storage which will show that there are no locations available for these materials to enter the canister.

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.

Strategy

Borosilicate glass is an inorganic material. Prior to entry into the Vitrification Facility, the canisters will be visually inspected to ensure that no observable organic material is present.

Compliance

Borosilicate glass, is an inorganic material. Organics in the melter feed will decompose in the melter. Standard test methods for assessing the amount of ash from organic materials, i.e., ASTM D482-80 and ASTM E830-81 use temperatures of 575°C to 775°C to decompose the organic molecules. These temperatures are less than the operating temperature of the melter, 1150°C. Therefore, no organics will remain in the glass.

The canisters will be cleaned, degreased, and visually inspected by the fabricator according to applicable sections of ASTM A 380. Certification that this took place will be required from the fabricator. The receipt of this certification will be recorded on production records. Before use the canisters will be stored in a clean, dry environment. Prior to entry into the vitrification

facility, the canisters will be visually inspected to ensure that organics used during fabrication were removed. Production records will show that this inspection took place. Furthermore, the heat of the glass pouring into the canister will cause trace quantities of organics in the canister to decompose.

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 provide in the WCP the expected frequency distribution of free volumes in canistered waste forms.

Strategy

The WVDP plans to fill its canisters nominally 85 percent full.

During waste vitrification the free volume will be provided by dividing the canistered glass weight by the glass density and comparing the resultant fill volume with the internal canister volume.

Compliance

The WVDP is planning to fill its canisters nominally 85 percent full with a range of 80 percent to 90 percent. Therefore, the free volume in a canister is expected to be 10 percent to 20 percent with the nominal being 15 percent. The above values are based upon ongoing work at Pacific Northwest Laboratory's Radioactive Liquid Fed Ceramic (B-Cell) Melter. Their canistered glass level detection system is similar to one that West Valley is considering using. Other level detection systems are also under consideration for West Valley use.

The B-Cell level detection system is a vertical line of gamma detectors placed near the canister. When the canister is empty a Co-60 source is detected. As it is filled, the glass shields the Co-60 and emits the Cs-137 (Ba-137m) gamma. The glass level is inferred from the height of each detector that senses the change. The B-Cell target fill height has been 85 percent with a resultant range of generally 80 percent to 90 percent. Not enough canisters have been filled to provide a distribution within the range. The B-Cell canisters have not been weighed, and the influence of undetected porosity on void volume has not yet been assessed. Based on tests at the CTS using a similar or alternate level detection system the expected frequency distribution of free volumes in canistered waste form will be estimated. This will be reported in the WQR.

Nonreference canisters may be the West Valley evacuated canisters of which there will be at least three. These will be used to drain the melter at the end of the campaign, or if necessary, during the campaign, e.g., to remove crystals that may accumulate on the bottom of the melter. These canisters may only be half full and of nonstandard dimensions. Furthermore, the pipes connected to the evacuated canisters and dipped into the melter will contain waste glass. These will be cut off and placed in canisters that will result in additional partly filled canisters. One canister will be required for these pipes for each set of three evacuated canisters.

Estimates of the void volume in canistered waste forms will be provided through calculations that use the canister internal volume, glass density, and weight. The use of canister volume, glass density, and weight will include the presence of internal voids, if any, as well as the void on top of the canister. The nominal internal volume of the West Valley canister will be estimated from the canister fabrication drawings and specification, or measurements of canisters used during cold testing. The density of WVDP glass will be measured. This glass will be subjected to the same heat treatment as that expected during

canister cooling. This volume and density information will be documented in the WQR. During waste vitrification the weights of each empty canister will be measured prior to filling. The weight of each filled canister will also be measured. These weights will be recorded on the production records. The difference between these two sets of weights will equal the weight of glass present in a canister. The weight divided by the density of glass will be used to calculate the volume of glass present in each canister. The fraction of the filled volume in each canister will be calculated from the volume of glass present in the canister divided by the nominal internal canister volume. The free volume fraction is the difference between one and the fill volume fraction. This free volume will be documented in the production records for each canister.

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 producter 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.

Strategy

The WVDP will smear the canister external surfaces according to 10 CFR 71.87(i)(1) before shipout to the repository. The canistered waste forms will be visually inspected for visible glass.

Compliance

Before transport to the repository, the external surface of the canister will be smeared according to the procedure in 10 CFR 71.87(i)(1). Smearing will be done under the lifting flange, on the canister wall halfway up, and on the canister bottom. The "smears" will be counted using standard instruments and the results will be reported in the production records. If the smear results do not meet the specified limits, the canister will be decontaminated and smeared again. Canister decontamination techniques currently being considered for the WVDP are discussed in Appendix F for information.

Visual inspection of the canisters to ensure that no waste glass is adhering to the canister will be made before shipout either through shield windows or a television camera. The results of this inspection will be reported on production records. If glass is adhering to the canister after decontamination, it will be removed e.g., by mechanical or abrasive means.

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 variations 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 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.

Strategy

The projected heat generation rate will be calculated by ORIGEN2 using the projected radionuclide inventory as input. The same approach will be used for obtaining the heat generation rate of production canisters after the radionuclide inventory is estimated. ORIGEN2 will be used to account for decay until time of shipment.

Compliance

Heat generation rate in a canistered waste form is dependent upon the radionuclides in the canister. The projected radionuclide inventory in the canistered waste will be estimated as discussed in Section 1.2.1. The projected inventory in canistered waste with its range will be used as input to ORIGEN2 to calculate the expected heat generation rate and range. The expected heat generation rate will be reported in the WQR. The same approach will be used to provide the heat generation rate at the time of shipment, i.e., the radionuclide inventory for the canistered waste will be estimated during waste

vitrification as discussed in Section 1.2.2. The inventory will be decayed to the appropriate time and converted to heat generation rate by ORIGEN2. This will be reported in the production records. The same accuracy considerations applied to the radionuclide inventory will be applied to heat generation and reported in the WQR.

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.

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.

Strategy

Using the radionuclide inventory as input QAD supplemented by ANSIN will be used to calculate canister surface neutron and gamma fluxes. These will then be converted to dose rates.

Compliance

Gamma and neutron surface dose rates for the canistered waste form depends on the radionuclide inventory and the characteristics of the glass media (e.g., density). The projected radionuclide inventory in

the canistered waste will be estimated as discussed in Section 1.2.1. The gamma and neutron source strength thus calculated will be input to QAD [20] and supplemented with ANISN[21]. The energy dependent flux at the surface of the West Valley canister will be calculated assuming the source to be uniformly distributed inside the canister. The energy dependent flux at the surface will then be converted into gamma or neutron dose using appropriate conversion factors. The expected dose rates will be reported in the WQR.

The same approach will be used to provide the dose rates at time of shipment. The radionuclide inventory will be estimated as discussed in Section 1.2.2. The dose rates will be calculated using the above codes and reported on the production records.

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.

Strategy

Existing data and calculations have been used to show that the canister does not react with the solidified glass. The moisture content in the canister void space and resultant potential canister corrosion will be estimated.

Compliance

Evidence indicates that significant internal corrosion of the canister will not occur as a result of the canister material being in contact with a solidified glass waste form at temperatures up to the glass transition temperature (approximately 500°C). A temperature low enough to reduce the mobility of the glass below that capable of aggressive attack would be expected to lie between the "softening point" (3.0×10^7 poise) and the "strain point" (3.2×10^{14} poise [22]). At temperatures below 500°C, borosilicate waste glass viscosities are at or above 10^{13} poise [23]. This viscosity is great enough to ensure that the glass will not cause significant internal corrosion of the canister. Any reaction that might occur can't proceed very far because the diffusion of reactants to the glass-metal interface, and of reaction products away from this interface, will be extremely slow in both the glass and in the metal from which the canister will be fabricated.

The West Valley canister will be fabricated from 304 stainless steel. Corrosion data is available for 304L stainless steel. The differences between the two metals are slight: 304 has a higher carbon content than 304L, 0.08 percent maximum, versus 0.03 percent maximum, and 304 has a lower Ni content, nine versus ten percent. These differences do not significantly impact the conclusions reached in the following studies.

In a study conducted by Oak Ridge National Laboratory, various canister and waste form materials were held in contact at temperatures of 100 and 300°C in air and He atmospheres for periods of 6888 and 8821 h [24] was reported that no significant interaction was detected between a typical borosilicate waste glass and 304L stainless steel. This conclusion is based on a visual examination of the surface of the metal where it had been in contact with the glass, and weighing of the glass and metal before and after the testing.

Other waste form-canister material compatibility studies have been conducted by Savannah River Laboratory in support of the Defense Waste Processing Facility. In one study, a borosilicate waste glass was melted and cast in 304L stainless steel crucibles. After being annealed at 500°C and furnace

cooled, the crucibles were held at 350°C for 10,000h. A metallographic examination was used to determine the changes in the dimensions of cross sections of the crucibles that had been in contact with the glass. From this examination it was determined that no significant corrosion of the crucibles had occurred [25]. In a second series of tests conducted in the same manner, no detectable corrosion was noted after the crucibles of glass had been held at 600°C for 20000h [26].

Corrosion tests have been done at PNL using a procedure adapted from the ANSI/ASTM C 621-68 "Standard Method for Static Test for Corrosion Resistance of Refractories to Molten Glass." In one series of tests, 304L stainless steel was subjected to a glass that is similar in composition to WV-205. The composition of glass used in these tests, TDS-411, is shown below:

Component	Wt%	Component	Wt%
SiO_2	42.2	Fe_2O_3	15.1
B_2O_3	7.8	NiO	1.9
AL_2O_3	3.1	MnO_2	4.0
Li_2O	8.8	Zeolite	2.5
Na_2O	9.0	Na_2SO_4	0.4
CaO	5.2		

The corrosion behavior found in these tests is representative of what would be expected if 304 were tested using WV-205 glass. At 1150°C the bulk corrosion rate of 304L in TDS-411 glass was 18 micrometers per day. The flux line corrosion (corrosion at the top surface of the glass where the metal, glass, and furnace atmosphere are all present) was 78 micrometers per day. At 1050°C corrosion rates were found to be significantly lower, 0 micrometers per day for the immersed portion of the specimen and 9 micrometers per day at the flux line. Based on these data, corrosion rates would be expected to decrease to essentially zero as temperatures approach 800 to 850°C. At 500°C, the temperature range in which the glass transition temperature is found, no detectable corrosion would occur.

The conclusion of these tests is that the waste form will not lead to internal corrosion of the canister.

The amount of corrosion that could result from moisture trapped with the air in the cannister void space after closure will be calculated. The approach will be to calculate the maximum weight loss of metal that could occur assuming that all of the water and oxygen in the canister airspace reacts with the canister wall. The calculated weight loss then will be converted to a penetration thickness to determine the extent of uniform corrosion. The kinetics of corrosion reactions will be ignored; only the ultimate extent of corrosion is deemed important. Uniform and non-uniform corrosion, i.e., intergranular corrosion, stress corrosion cracking, and pitting, will be addressed.

The following assumptions will be made:

- The canister is filled with glass to 70 percent of its height. This is a conservative assumption because the West Valley canisters are expected to be filled to at least 80 percent of their height (so there will be less air volume per unit surface area of canister wall).

- Dry air is 21 percent by volume oxygen.

- All metal atoms in the stainless steel, designated as M, have a molecular weight of 55.4 g/g-mole, which is the average molecular weight of the stainless steel (based on a composition of 19 percent Cr, 9 percent Ni, and Fe as the balance):

$$0.19(52.0) + 0.09(58.7) + 0.72(55.85) = 55.4 \text{ g/g-mole}$$

- All water reacts with M to form $M(OH)_2$.

- All oxygen not participating in water reactions reacts with M to form M_3O_4. M_3O_4 is believed to be the composition of the metal oxide in the protective film on the stainless steel surface [27].

The results of this analysis will be reported 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 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 forms to enable the repository designer to confirm subcriticality under repository storage and disposal conditions.

Strategy

K_{eff} for the canistered waste will be calculated using the KENO system. It will be shown that K_{eff} is less than or equal to 0.95.

Compliance

The criticality calculations for the canistered waste will be performed by the Criticality Safety Engineer as required in the WVDP Radiological Controls Manual.[28] The composition, radionuclide inventory including fissionable radionuclides, and fill volume of the canister will be estimated as explained in Sections 1.1, 1.2, and 3.5, respectively. These and the canister geometry (Figure 3) will be input to the KENO computer code.[29] (KENO validation will involve the use of existing experimental/calculational results). The calculated reactivity of the canistered waste form will be shown to be less than or equal to 0.95 within a 95 percent probability and 95 percent confidence level. The value for K_{eff} for each canister will be recorded on the production records. Normal operating conditions and credible accident scenarios at West Valley will be considered. The WQR will

report the reactivity for the compositions developed during the waste variability study discussed in Section 1.1.1 that are most likely to be a criticabilty concern (e.g., lowest boron). The amount of fissionable radionuclides used in this analysis will be conservatively based upon a canister with maximum waste loading and will assume the fissionable radionuclides are uniformly dispersed in the glass matrix. The WQR will also report the nuclear characteristics of the canistered waste. This will include the final canister geometry, variations of the glass composition, and fissionable radionuclide concentrations. This will ensure that the canistered waste forms will be subcritical prior to the start of waste vitrification.

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.

Strategy

The canisters will be weighed before shipment to the repository.

Compliance

The canistered waste forms will be weighed by a scale attached to the crane or by a platform scale when the canisters are being moved for shipment to the repository. This weight measurement will be made after the permanent closure process has been completed. The specification for this scale will require that it measure the

weight accurate to within ±5%. Other weight measurements may be made prior to that time to calculate free volume in a canister (see Specification 3.5). Canistered waste form weights will be recorded on the production records.

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 0.34 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.

Strategy

A correlation between the prepour and postpour lengths and diameters will be developed during nonradioactive testing at West Valley. From this, dimensions and tolerances will be developed for canister fabrication.
The minimum postpour wall thickness will be estimated by measuring the thickness loss to stainless steel in contact with the nonradioactive pouring glass.

Compliance

During nonradioactive preoperational systems testing, West Valley will produce a number of filled canisters. The pre and postpour lengths and diameters of these canisters will be measured. From these measurements, a correlation between the two lengths and

diameters will be developed. From this correlation, a range of prepour canister lengths and diameters will be determined that will yield production canisters whose lengths and diameters are within the range given in the specification at 20°C. All of the above information will be documented in the WQR. For the canisters used during production, West Valley will include in the fabrication specification the prepour lengths and diameters of their canisters to assure that they are within the range that will produce filled canisters whose time-of-production length and diameters are within the correct range. These prepour lengths and diameters at an ambient temperature of about 20°C will be recorded on the production records.

The postpour wall thickness estimate of the West Valley canister will be based on measurements of stainless steel exposed to glass pouring during nonradioactive cold testing. The stainless steel exposed to the glass pouring will be either the walls of test canisters or test coupons. The stainless steel used in these tests will be certified as 304 stainless steel and as having the same surface finish as that expected for the canister. Thicknesses will be measured before the test. The stainless steel will then be exposed to the glass pour stream. After the glass has cooled, it will be removed from the metal. The thickness will then be measured to asses the amount of material lost from the canister. The amount of material lost will be subtracted from the minimum wall thickness. This value will be reported in WQR. The average and range of the measurements will be reported.

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 canister will stand upright without support on a flat horizontal surface and will fit without forcing when lowered vertically into a right-circular, cylindrical cavity 64.0 cm in diameter and 3.01 m in length.

Strategy

Canisters filled during nonradioactive testing at West Valley will be inserted in a test cylinder with a diameter of less than 64 cm.

Compliance

West Valley has a steel cylinder with an inner diameter less than 64.0 cm and a length of 300 cm. Nonradioactive canisters filled during testing will be inserted into this test cylinder as a part of the canister pre and postfill characterization to verify that the canister fits without forcing and can stand without support on a flat horizontal surface. The length of the test cylinder is 1cm less than the specification to account for the absence of the final closure on the test canisters. The results of these tests will be reported in the WQR.

3.12 Drop Test Specification

The canistered waste form at time of shipment shall be capable of withstanding a drop of 7 m [R3] 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.

Strategy

A stress analysis will be performed on the West Valley canister. A West Valley canister filled during nonradioactive testing will be dropped on its bottom center.

Compliance

Discussions with representatives of the repository projects indicate that the intent of this specification is to provide a measure of the integrity of the canister. A height for the drop test has not been fixed (see R3 of Appendix B). After the drop, the canister should still be capable of being uprighted from a horizontal to a vertical position, picked up, and placed into the standard repository container (see overall dimensions of Specification 3.11). Compliance with the intent of this specification can be shown by doing the above without losing significant quantities of the waste glass. Breaching in this specification is not necessarily related to the leak tightness specification of Specification 2.2.

A stress analysis will be performed on the West Valley canister to estimate the maximum height that the canister can be dropped without failing. Failure will be when the metal is expected to fracture. The analysis will consider drops with the canistered waste form center of gravity over the bottom center, bottom corner, and top center. For these analyses it will be assumed that the canister is 90 percent full with all of the void volume on top.

The results of the above analyses will be confirmed by dropping a glass filled West Valley canister generated during nonradioactive testing at the CTS. The WVDP is monitoring the development of MCC-15,[30] which is currently in a draft stage, for use as a procedure for a drop test. A full scale canister filled 85 percent to 90 percent full will be dropped on a flat essentially unyielding surface with the center of gravity over the bottom center. The height will be at about the height indicated for failure by the stress analysis. Prior to the test a lid will be welded to close the canister. Before and (if appropriate) after drop testing the canister will be inspected using dye penetrant examination and leak testing. After impact, if any glass is observed leaking from the canister, it will be qualitatively

recorded, e.g., by a photograph. Strain on the canister in the vicinity of the impact will be characterized. The length, diameter, and overall dimensions will be characterized. The results of the stress analyses and drop tests will be documented in the WQR.

3.13 Handling Features Specification

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

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

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

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

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

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

The design of the flange and the grapple shall be capable of fulfilling the requirements of Specifications 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 inadvertent 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 detailed designs in the WQR.

Strategy

The lifting flange geometry for the West Valley canister is shown in Figure 3. The grapple concept is illustrated in Figure 5.

Compliance

The lifting flange geometry is included in Figure 3. The lifting flange for the canisters will be load tested at 2720 kg. (This is about 200kg greater than a 100 per cent full canister is expected to weigh.) A conceptual design of the grapple being tested at West Valley is shown in Figure 5. The design of the grapple is being remotized. The grapple is being designed and will be tested to verify that it meets the requirements of 3.13(a) to 3.13(c) without penetrating the walls of an imaginary right circular cylinder with diameter equal to the canister. When attached to a crane, the grapple will be able to lift the canister vertically. The design will also consider positive assurances against inadvertent release of a suspended canister. The detailed design of the remotized grapple and codes and standards that will be used during its fabrication will be given in the WQR.

WEST VALLEY CANISTER GRAPPLE

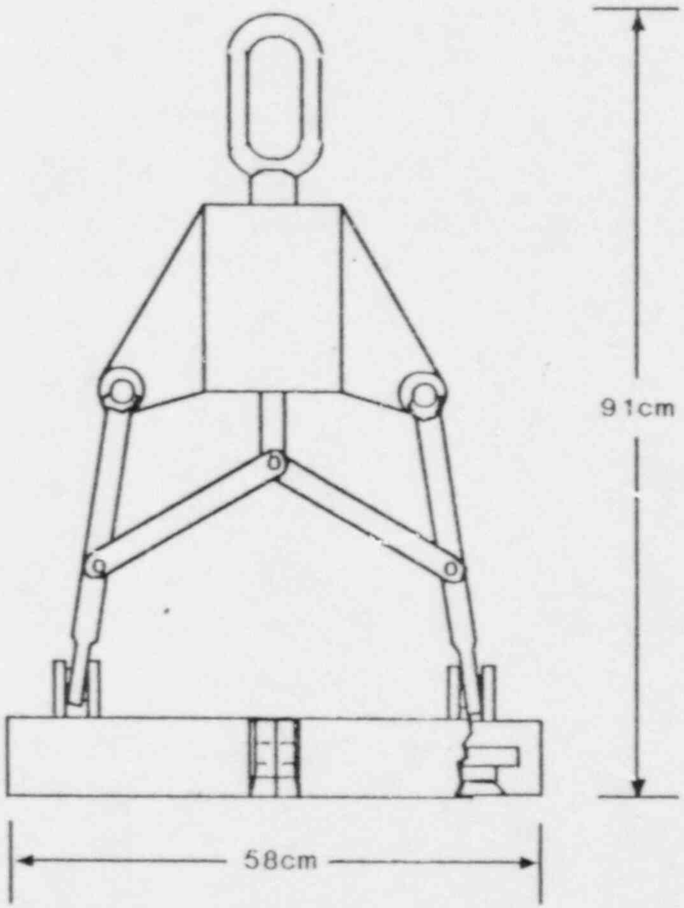

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FIGURE 5

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4.0 QUALITY ASSURANCE SPECIFICATION

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

Compliance

The WVDP is a high-level waste management demonstration project under the direction of the Department of Energy (DOE). The West Valley Nuclear Services Co. Inc. (WVNS) has been contracted by the DOE to carry out this project. The primary interface between DOE and WVNS is carried out by a project personnel and the DOE site office staff. WVNS has extablished a quality assurance program (QAP) to control the project. This program has been reviewed and approved, and is periodically audited by the DOE.

The WVDP Quality Assurance Organization has been assigned the responsiblity to implement a quality assurance program meeting the requirements defined below. The Manager, Quality Assurance, reports directly to the Project Manager (President, WVNS) and has been given the organizational authority and independence to develop and implement the program. This authority includes maintaining liaison with the DOE, issuing and controlling the Quality Management Manual, monitoring

ongoing activities, identifing and resolving quality problems, assuring effective implementation of the Quality Assurance program, and stopping work whenever continuation of work would potentially cause product damage or perso al injury.

The QAP for high-level waste compliance at the WVDP is a broad base program meeting the requirements of "Quality Assurance Management Policies and Requirements."[31] The West Valley Quality Assurance Program for HLW compliance is based upon and meets the applicable requirements of ANSI/ASME NQA-1-1983,[32] which is also the basis used by the Office of Civilian Radioactive Waste Management in Ref. 25. The basic requirements and supplements of NQA-1 are applied as appropriate to activities associated with waste form production, canisterization, and preparation for storage and shipment as necessary to insure that these activities conform to Waste Acceptance Preliminary Specifications[7] (WAPS). The program is also in compliance with appropriate DOE QA directives (5700.6B) and is consistent with federal regulation (10CFR50, Appendix B).

Each activity has the applicable program elements applied to it that are essential to assure that the activity is controlled in such a manner to produce a canistered high-level waste form of known characteristics, such as chemistry and geometry, with traceable documented evidence of its compliance to the requirements of the WAPS.

At the WVDP the Quality Assurance Department is directly involved in the processes of waste form testing and production; canister design, development, testing, and procurement; waste canisterization; and preparation for storage and shipment. In this role Quality Assurance is performing quality engineering reviews of all activities including design, procurement, fabrication, assembly, and testing. Quality Assurance will also develop and implement surveillance and inspection plans including process control verification programs for on-going waste form production and storage activities. Quality Assurance will perform

a thorough review and approval of the data produced to support the acceptability of the canistered waste form to the requirements of the WAPS. The data for the WQR and the production records will be generated through a series of tests. Therefore, test control is the emphasis of the QAP and is discussed below.

4.1 WVDP Quality Assurance Program for Testing

4.1.1 Introduction

The WVDP Quality Assurance Program for testing encompasses the testing programs for glass characterization, the proof testing of the stainless steel canister, the production and testing of nonradioactive canistered glass, the production of the radioactive canistered waste glass, and handling and storage of filled canisters. The testing program as defined by the controlling engineering procedures is the administrative system for all activities at the WVDP from waste form characterization through production and initial storage at the WVDP.

4.1.2 Test Program

The test program at the WVDP is defined and controlled by established Quality Assurance procedures (QM 11, QAP 11-1) and Engineering Procedures. (EP-11-001) The essential elements of the program as described in these documents are:

- Definition of test requirements
- Test planning
- Test specifications
- Test procedures
- Test reports

- Formal review and acceptance of test results.
- Records

The WVDP has developed a formal test plan for preparation of an acceptable HLW glass form, canisterization of the glass and preparation of the WQR. A simplified schedule for this test plan is attached (Figure 6).

An essential element of current test planning is the series of test specifications (run plans) that have been and are being developed to sequentially and logically prove the acceptability of the glass composition. This series of tests, Functional and Checkout Testing of Systems (FACTS), are process development tests (through SF-11) followed by closely controlled and documented proof of process tests (SF-12 through SF-15) which will result in a canistered HLW glass form with documented evidence of compliance to the WAPS.

The process development tests (through SF-11), which are the early stage tests used by the project to provide proof of principal information concerning glass chemistry and process parameters, have Quality Assurance involvement through review and concurrence with the run plans and test procedures. Additionally, Quality Assurance performs surveillances of the the ongoing test activities. The tests are subject to standard engineering controls defined in the administrative test procedures to the extent that the results will be used to provide support to the Waste Qualification Report. As a minimum, basic test control features such as calibrated instruments, detailed procedures (as applicable) with sign-offs and procedure reporting are in affect.

WASTE COMPLIANCE SCHEDULE

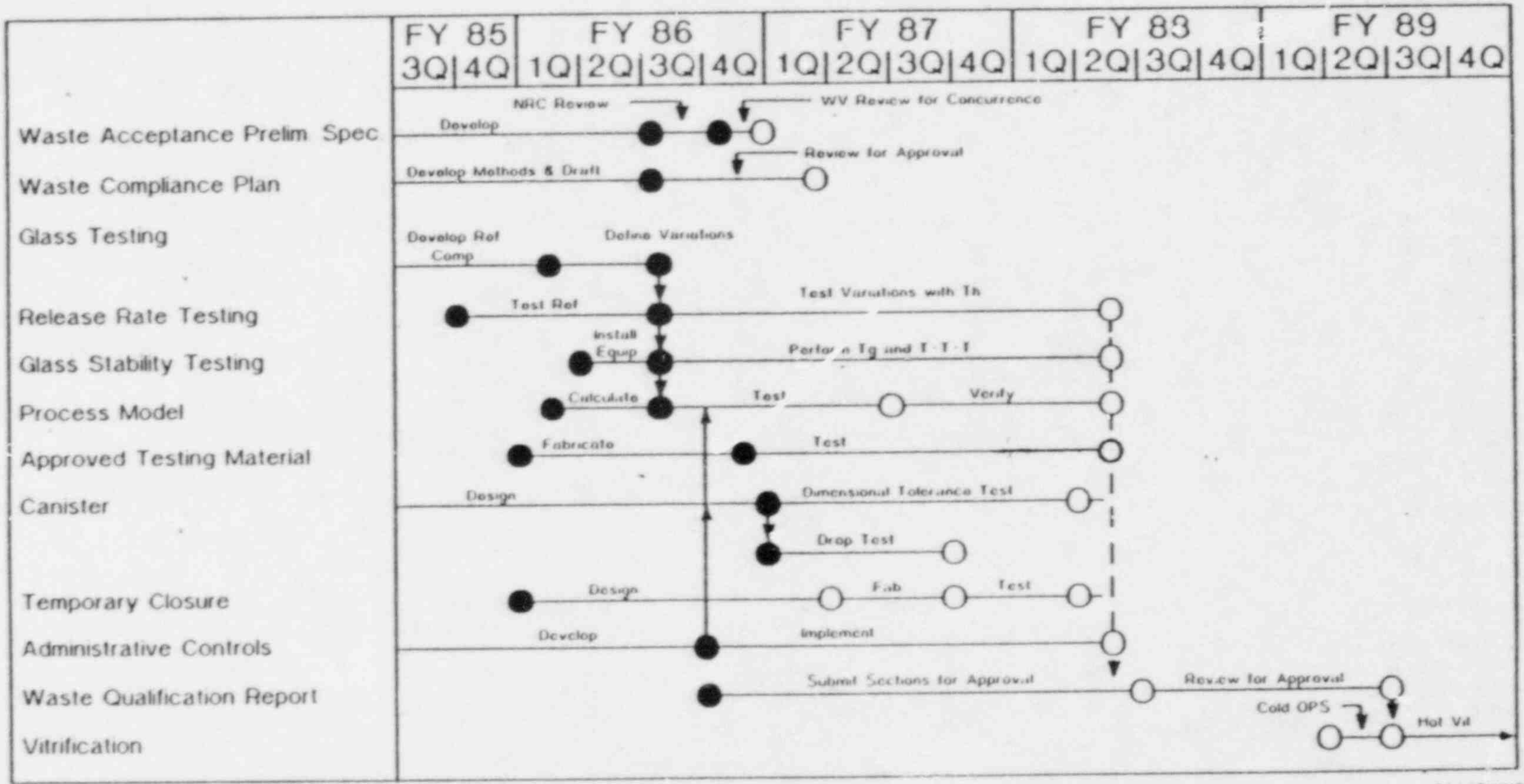

FIGURE 6

The qualification testing beginning with SF-12 requires that more stringent controls be imposed on the test process since this data will be included in the Waste Qualification Report. The requirements of the engineering procedure governing performance of this testing will state that:

- o Test specifications be prepared (the WCP will serve this purpose).
- o Detailed test procedures be issued, reviewed, and approved by appropriate organizations.
- o Test procedures contain appropriate sign-offs by operator and overview organizations. To the extent required by the complexity of the run plan, test procedures will be prepared, reviewed and approved by the participating organizations, generally Operations, Engineering, and Quality Assurance.The test procedures provide for detailed step by step sequencing including appropriate sign off by performers, as well as inspection and overview by Quality Assurance.
- o Test reports be prepared, reviewed, and approved.
- o The results of tests be reviewed and approved by representative independent peer groups (including QA) as appropriate to assure that the results provide acceptable evidence that the requirements of the WAPS have been met.

4.1.3 Control of Process Materials

Certain materials and items are required to support the testing program for proving the acceptability of

the canistered waste form. Material control will be accomplished by requiring, where appropriate, that suppliers be qualified, that during procurement source surveillance and receipt inspection be performed, that suppliers provide appropriate materials certification data (CMTRs, etc.), that independent testing be performed by WVDP to support suppliers analyses, and that the WVDP material control program be applied after receipt of materials.

4.1.4 Canister Qualification

Canister qualification will be controlled. Testing will be performed in accordance with procedures and be subject to reviews and approvals of Quality Assurance and independent review teams to assure that the requirements of the WAPS are met and that the test results are documented, reviewed, approved, and verified. To assure that acceptable canisters are available to receive processed glass, the WVDP will require that the supplier be qualified. The WVDP will perform surveillances of in process activities and will maintain close control of the canisters after receipt at the WVDP to assure that material integrity is maintained.

The supplier will also be required to maintain material control throughout the fabrication process. He will perform appropriate NDE and dimensional examinations of assembled canisters which will be periodically witnessed by Quality Assurance. Each canister will also have a detailed data package provided by the supplier and reviewed and approved by WVDP prior to acceptance at West Valley.

4.1.5 Subcontractors

Subcontractors will perform work under the requirements of the WVDP QAP. Where appropriate they may have or will establish a Quality Assurance Program covering the applicable elements of NQA-1. If applicable, a plan will be prepared and implemented by detailed Quality Assurance procedures. Technical lab procedures will be written for all work being performed. When the subcontractor has a QAP, he will have the primary responsibility for controlling and insuring that all work will be performed in accordance with their established Quality Assurance Program. The subcontractor will be involved in the training programs related to implementation of the Quality Assurance Program. He will perform frequent surveillances to insure that all activities being performed are in compliance with the established controlling procedures. An internal quality assurance audit program will be implemented. WVDP will work closely with the subcontractor as necessary in monitoring the development of the Quality Assurance Program. The program will address the activities that are important to assuring that the data produced will be acceptable as part of the Waste Qualification Report. The WVDP will perform surveillances and audits of on going work to insure that the final formal data transmitted to West Valley will be verifiable, traceable, and documented in a clear conducive manner. West Valley verifications and surveillances will concentrate on computer software program control, test control, data analysis and traceability, procurement control, calibration control, procedure compliance, and Quality Assurance Program compliance.

4.1.6 Control of Computer Software

Computer software that is used to develop, support, or prove the acceptability of the waste form or the waste form process shall be subject to controls identified in the Quality Assurance Program. These controls shall assure that the software has appropriate verification and validation prior to use to assure its adequacy and accuracy. Computer codes shall be documented such that all appropriate concerns are addressed.

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APPENDIX A

WVDP LIQUID HLW CHARACTERISTICS

TABLE A-IA: PUREX (8D-2 TANK) INSOLUBLE SOLIDS
REFERENCE CHEMICAL COMPOSITION

Component	Mass (kg)
Fe(OH)3	66,040
FePO4	6,351
Al(OH)3	5,852
AlF3	536
MnO2	4,581
CaCO3	3,208
UO2(OH)2	3,087
Ni(OH)2	1,088
SiO2	1,263
Zr(OH)4*	159
MgCO3	826
Cu(OH)2	376
Zn(OH)2	128
Cr(OH)3	65
Hg(OH)2	23
Fission Products**	
Rare Earth Hydroxides	1,464
Other hydroxides	1,485
Sulfates	520
Transuranics	
NpO2	38
PuO2	37
AmO2	19
CmO2	0.1
Total	97,166

*Excludes fission product zirconium
**See Table A-IB for breakdown

TABLE A-1B: PUREX SOLIDS FISSION PRODUCTS

Rare Earths	
$Nd(OH)_3$	621
$Ce(OH)_3$	354
$La(OH)_3$	185
$Pr(OH)_3$	170
$Sm(OH)_3$	143
$Eu(OH)_3$	7.5
$Gd(OH)_3$	1.7
$Pm(OH)_3$	1.5
Other Components	
$Zr(OH)_4$	805
$Ru(OH)_4$	458
$BaSO_4$	303
$SrSO_4$	217
$Y(OH)_3$	103
$Rh(OH)_4$	79
$Pd(OH)_2$	34
$Sn(OH)_4$	2.5
$Cd(OH)_2$	1.7
$Sb(OH)_3$	0.7

TABLE A-II: PUREX SUPERNATANT CHEMICAL COMPOSITION

Compound	Wt. Percent Wet Basis	Wt. Percent Dry Basis	Mass (kg)
NaNO3	21.10	53.38	602,659
NaNO2	10.90	27.57	311,326
NaSO4	2.67	6.76	76,261
NaHCO3	1.49	3.77	42,557
KNO3	1.27	3.21	36,274
Na2CO3	0.884	2.24	25,249
NaOH	0.614	1.55	17,537
K2CrO4	0.179	0.45	5,113
NaCl	0.164	0.42	4,684
Na3PO4	0.133	0.34	3,799
Na2MoO4	0.0242	0.06	691
Na3BO3	0.0209	0.05	597
CsNO3	0.0187	0.05	534
NaF	0.0176	0.04	503
Sn(NO3)4	0.00859	0.02	245
Na2U2O7	0.00808	0.02	231
Si(NO3)4	0.00806	0.02	230
NaTcO4	0.00620	0.02	177
RbNO3	0.00416	0.01	119
Na2TeO4	0.00287	0.007	82
AlF3	0.00271	0.007	77
Fe(NO3)3	0.00152	0.004	43
Na2SeO4	0.00054	0.001	15
LiNO3	0.00048	0.001	14
H2CO3	0.00032	0.0008	9
Cu(NO3)2	0.00022	0.0005	6
Sr(NO3)2	0.00013	0.0004	4
Mg(NO3)2	0.00008	0.0002	2
Total	39.53	100.00	1,129,038
H2O (By Difference)	60.47		1,727,164

TABLE A-III: THOREX WASTE REFERENCE CHEMICAL COMPOSITION

Compound	Weight Percent	Mass (kg)	Compound	Weight Percent	Mass (kg)
Th(NO3)4	34.53	31,054	Zr(NO3)4	0.014	12
Fe(NO3)3	9.41	8,462	Na3PO4	0.013	12
Al(NO3)3	4.64	4,175	NaTcO4	0.013	12
HNO3	3.12	2805	Y(NO3)3	0.012	11
Cr(NO3)3	2.13	1,918	Rh(NO3)4	0.012	11
Ni(NO3)2	0.88	791	Zn(NO3)2	0.011	10
H3BO3	0.53	480	Pd(NO3)4	0.0084	8
NaNO3	0.25	227	UO2(NO3)2	0.0063	6
Na2SO4	0.20	180	RbNO3	0.0067	6
KNO3	0.14	128	N[illegible]e04	0.0058	5
Na2SiO3	0.14	126	Co(NO3)2	0.0028	3
K2MnO4	0.14	122	Na2SeO4	0.0013	1
Mg(NO3)3	0.063	57	NaF	0.0012	1
Na2MoO4	0.061	54	Eu(NO3)3	0.0011	1
NaCl	0.056	50	Np(NO3)4	0.0010	0.9
Nd(NO3)3	0.051	46	Sn(NO3)3	0.00098	0.9
Ce(NO3)4	0.048	43	Cu(NO3)2	0.00086	0.8
Ru(NO3)4	0.047	42	Pa(NO3)4	0.00074	0.7
ZrO2*	0.039	35	Pu(NO3)4	0.00073	0.7
Ca(NO3)2	0.034	30	Gd(NO3)3	0.00039	0.3
CsNO3	0.031	28	Cd(NO3)2	0.00031	0.3
Ba(NO3)2	0.030	27	X(NO3)4**	0.00025	0.2
La(NO3)3	0.025	22	Sb(NO3)3	0.00017	0.1
Pr(NO3)3	0.023	21	AgNO3	0.00009	0.08
Sr(NO3)2	0.018	16	In(NO3)3	0.00004	0.04
Sm(NO3)3	0.016	14	Pm(NO3)2	0.00002	0.02
			Total	56.77	51,057
			H2O (by difference)	43.23	38,875

*Insolubles Assumed to be ZrO2
**Am, Cm and Misc. Actinides

Table A-IV: Reference 1987 Radionuclide Content (Curies) of West Valley Waste‡

Nuclide	-------PUREX---------- Supernatant	Solids	THOREX	WTF Total
3-H	9.74E+01	0.00E+00	1.74E+00	9.91E+01
14-C	1.37E+02	0.00E+00	0.00E+00	1.37E+02
55-Fe	0.00E+00	1.00E+03	5.63E+02	1.56E+03
60-Co	0.00E+00	4.70E+00	1.14E+03	1.14E+03
59-Ni	0.00E+00	8.56E+01	2.03E+01	1.06E+02
63-Ni	8.89E+02	5.35E+03	2.51E+03	8.75E+03
79-Se	5.66E+01	0.00E+00	3.35E+00	6.02E+01
90-Sr	2.89E+03	6.74E+06	4.54E+05	7.20E+06
90-Y	2.89E+03	6.74E+06	4.54E+05	7.20E+06
93-Zr	2.56E-01	2.56E+02	1.62E+01	2.72E+02
93m-Nb	1.59E-01	1.59E+02	1.02E+01	1.69E+02
99-Tc	1.60E+03	0.00E+00	1.04E+02	1.70E+03
106-Ru	1.10E-01	1.10E+02	6.24E-01	1.11E+02
106-Rh	1.10E-01	1.10E+02	6.24E-01	1.11E+02
107-Pd	1.09E-02	1.09E+01	1.14E-01	1.10E+01
113m-Cd	2.41E+00	2.41E+03	3.75E+01	2.45E+03
121m-Sn	1.76E-02	1.76E+01	5.99E-01	1.82E+01
126-Sn	1.01E-01	1.01E+02	3.11E+00	1.04E+02
125-Sb	4.90E+01	1.31E+04	2.89E+02	1.54E+04
126-Sb	1.42E-02	1.42E+01	4.35E-01	1.46E+01
126m-Sb	1.01E-01	1.01E+02	3.11E+00	1.04E+02
125m-Te	3.49E+00	3.49E+03	6.68E+01	3.56E+03
129-I	2.10E-01	0.00E+00	1.80E-01	3.90E-01
134-Cs	1.39E+04	0.00E+00	3.10E+02	1.42E+04
135-Cs	1.56E+02	0.00E+00	5.47E+00	1.61E+02
137-Cs	7.26E+06	0.00E+00	4.75E+05	7.74E+06
137m-Ba	6.87E+06	0.00E+00	4.49E+05	7.32E+06
144-Ce	2.97E-05	9.21E+00	1.39E-01	9.35E+00
144-Pr	2.97E-05	9.21E+00	1.39E-01	9.35E+00
146-Pm	1.41E-04	2.10E+01	6.06E-01	2.16E+01
147-Pm	1.67E+02	1.85E+05	9.11E+03	1.94E+05
151-Sm	1.10E+00	8.15E+04	4.78E+03	8.63E+04
152-Eu	4.25E-02	3.77E+02	4.82E+01	4.25E+02
154-Eu	1.37E+01	1.19E+05	2.53E+03	1.22E+05
155-Eu	2.37E+00	3.54E+04	8.44E+02	3.62E+04
207-Tl	0.00E+00	9.12E-04	7.50E+00	7.50E+00
208-Tl	0.00E+00	4.28E-02	3.51E+00	3.55E+00
209-Pb	0.00E+00	6.61E-06	2.07E-01	2.07E-01
211-Pb	0.00E+00	9.14E-04	7.52E+00	7.52E+00
212-Pb	0.00E+00	1.19E-01	9.76E+00	9.88E+00
211-Bi	0.00E+00	9.14E-04	7.52E+00	7.52E+00
213-Bi	0.00E+00	1.19E-01	9.76E+00	9.88E+00
213-Bi	0.00E+00	6.61E-06	2.07E-01	2.07E-01
212-Po	0.00E+00	7.62E-02	6.25E+00	6.33E+00
213-Po	0.00E+00	6.47E-06	2.03E-01	2.03E-01
215-Po	0.00E+00	9.14E-04	7.52E+00	7.52E+00
216-Po	0.00E+00	1.19E-01	9.76E+00	9.88E+00

Nuclide	-------PUREX---------- Supernatant	Solids	THOREX	WTF Total
217-At	0.00E+00	6.61E-06	2.07E-01	2.07E-01
219-Rn	0.00E+00	9.14E-04	7.52E+00	7.52E+00
220-Rn	0.00E+00	1.19E-01	9.76E+00	9.88E+00
221-Fr	0.00E+00	6.61E-06	2.07E-01	2.07E-01
223-Fr	0.00E+00	1.26E-05	1.04E-01	1.04E-01
223-Ra	0.00E+00	9.14E-04	7.52E+00	7.52E+00
224-Ra	0.00E+00	1.19E-01	9.76E+00	9.88E+00
225-Ra	0.00E+00	6.61E-06	2.07E-01	2.07E-01
228-Ra	0.00E+00	4.81E-09	1.48E+00	1.48E+00
225-Ac	0.00E+00	6.61E-06	2.07E-01	2.07E-01
227-Ac	0.00E+00	9.14E-04	7.52E+00	7.52E+00
228-Ac	0.00E+00	4.81E-09	1.48E+00	1.48E+00
227-Th	0.00E+00	9.01E-04	7.42E+00	7.42E+00
228-Th	0.00E+00	1.19E-01	9.76E+00	9.88E+00
229-Th	0.00E+00	6.61E-06	2.07E-01	2.07E-01
230-Th	0.00E+00	1.45E-02	4.38E-02	5.83E-02
231-Th	6.41E-03	8.94E-02	5.17E-03	1.01E-01
232-Th	0.00E+00	5.87E-09	1.64E+00	1.64E+00
234-Th	5.71E-02	7.97E-01	7.11E-05	8.54E-01
231-Pa	0.00E+00	2.86E-04	1.52E+01	1.52E+01
233-Pa	0.00E+00	2.30E+01	3.02E-01	2.33E+01
234m-Pa	5.71E-02	7.97E-01	7.11E-05	8.54E-01
232-U	3.13E-01	4.36E+00	2.74E+00	7.41E+00
233-U	4.98E-01	6.94E+00	2.09E+00	9.53E+00
234-U	2.80E-01	3.90E+00	2.17E-01	4.40E+00
235-U	6.41E-03	8.94E-02	5.17E-03	1.01E-01
236-U	1.91E-02	2.67E-01	9.80E-03	2.96E-01
238-U	5.71E-02	7.97E-01	7.11E-05	8.54E-01
236-Np	0.00E+00	9.35E+00	1.23E-01	9.47E+00
237-Np	0.00E+00	2.30E+01	3.02E-01	2.33E+01
239-Np	0.00E+00	3.43E+02	4.49E+00	3.47E+02
236-Pu	1.36E-02	8.24E-01	1.09E-02	8.49E-01
238-Pu	1.27E+02	8.00E+03	4.80E+02	8.61E+03
239-Pu	2.54E+01	1.61E+03	1.54E+01	1.65E+03
240-Pu	1.87E+01	1.18E+03	8.09E+00	1.21E+03
241-Pu	1.46E+03	9.23E+04	8.50E+02	9.46E+04
242-Pu	2.54E-02	1.61E+00	1.19E-02	1.65E+00
241-Am	0.00E+00	5.30E+04	2.41E+02	5.32E+04
242-Am	0.00E+00	2.94E+02	6.79E+00	3.01E+02
242m-Am	0.00E+00	2.94E+02	6.79E+00	3.01E+02
243-Am	0.00E+00	3.39E+02	7.83E+00	3.47E+02
242-Cm	0.00E+00	2.43E+02	5.59E+00	2.49E+02
243-Cm	0.00E+00	1.44E+02	2.34E-01	1.44E+02
244-Cm	0.00E+00	8.55E+03	1.37E+01	8.56E+03
245-Cm	0.00E+00	8.62E-01	2.00E-02	8.82E-01
246-Cm	0.00E+00	9.87E-02	2.29E-03	1.01E-01

‡Includes all Radionuclides totaling > 0.1 Curies in Vitrification Feed Prior to Year 3090

APPENDIX B

EXPLANATION OF RESERVED ITEMS

OF THE WASTE ACCEPTANCE

PRELIMINARY SPECIFICATIONS

R1 - Radionuclide Inventory Specification

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

R2 - Specification for Radionuclide Release Properties

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

R3 - Drop Test Specification

Specification 3.12 requires a drop test be performed from a height of 7 m. This value is being held in reserve pending testing analyses by WVDP.

APPENDIX C

GLASS DURABILITY TEST METHODS

SUMMARY OF STATIC LEACH TEST METHODS[10]

Specimens of known volume and geometric surface area are immersed in reference leachants without agitation for defined time periods at defined temperatures. The SA/V is held constant within 0.0005 of 0.0100mm^{-1}. Three reference temperatures, 40°C, 70°C, and 90°C, and a number of specific time periods are identified in a series of test matrices established to meet objectives that include rapid evaluation of waste forms for comparative understanding of their long-term leaching behavior. In the test method, three reference leachants maybe used: pure water and two solutions (silicate/bircarbonate and brine) that approximate fluids that the waste form may encounter in a geologic repository. In addition to the reference leachants, site-specific leachants or actual samples of repository water may be used. The test is for application to simulated waste forms and to radioactive specimens. When using Teflon leach vessels, the absorbed dose may not exceed 10^4 rad. Inert materials fc· the testing of radioactive specimens such as fused quartz and gold may be used when the absorbed dose will exceed 10^4 rad. There is no upper limit for the use of Teflon leach vessels for alpha-emitting isotopes. However, when the specimen activity times the test period exceeds 1.4×10^9 (Bq·h)/g, the Teflon must remain at least 1 mm away from the specimen.

SUMMARY OF PARTIAL-EXCHANGE INTERACTIVE FLOW TEST

The test procedure is based on partial exchange of the leachant in contact with the solid at fixed intervals until the composition of the leachate shows no further significant changes with time. (This requires the total exchanged volume to exceed three times the leachant volume in contact with the solid, and completion of the rapid initial processes such as the rapid dissolution of fines and surface irregularities and the rapid stage of build-up of surface layers.) This ensures the applicability of the test to the evaluation of long-term durability and the suppression of short-term transient effects. Continued repetitive sampling after the concentration readings have stabilized also makes it possible to obtain a very high degree of analytical accuracy.

The results of the test, based on the stabilized leachate concentration readings, maybe reported both in terms of conventional leach rates ($g \cdot m^{-2} \cdot d^{-1}$) and in terms of annual fractional releases (yr^{-1}). The latter representation is directly applicable to the evaluation of long-term durability.

The actual flow rate in the test is directly determined by the frequency of leachant exchange on one hand and by the ratio between the volume removed and changed and the total leachant volume in contact with the solid on the other hand.

However, the experimental flow rate can be translated into the effective flow rate under any given repository configuration by means of applying a simple scaling factor which consist of the quotient of the surface-to-volume ratio in the test configuration by the corresponding ratio in the case of the waste-form package.

The test should be carried out at several combinations of leachant-exchange frequency and surface-to volume ratio so as to cover the range of effective flow rates expected under service conditions and to include the flow rate at which the maximum corrosion rate occurs.

The measured leach rates or fractional release rates are reported as a function of both the contact or residence time and the effective flow rate.

The test specifications require that the test results will be reported only when comprehensive leachate analysis, including reliable pH measurements, shows a good agreement (within ±10 percent) between the analyzed levels of total cationic species and total anionic species, respectively. This requirement ensures that all major species which determine the reactivity of the medium toward the solid are identified and taken into account, and that the relative contribution of species originating in the test environment to the composition of the leachate, compared with the contribution of leached species, can be evaluated and controlled.

INTERACTIVE POWDER LEACH

TEST METHOD

Interactive Powder Leach Test Method

1.0 Scope

The powder leach test described below uses a technique which is intended to provide data on the leach behavior of solid waste forms (e.g. borosilicate glasses) under conditions of strong interaction between the waste form and water. When contact times between the waste glass and the water are sufficiently long, major changes in the composition, pH, and reactivity of the water take place due to prolonged interaction with the glass. The present method seeks to explore the leach behavior in the strongly interactive regime by using very high S/V ratios in order to obtain meaningful data within short testing periods.

2.0 Summary

Waste-form samples are pulverized into powders that are screened into a particle size between 149 and 74 microns. These are immersed in the leachant at a constant ratio of leachant volume to specimen mass 10 ± 0.1 mL/g. The test temperature is 90°C. The reference time period of the test is 7 days. Longer time periods are optional. The reference leachant is de-ionized water. Other leachants comprising actual and synthetic groundwater are optional.

A separate powdered specimen, leach container, and leachant are required for each data point. Test results are based on leachate analysis.

3.0 Safety

See section 3.0 of the MCC-3S Agitated Powder Leach Test Method (PNL-3990).

4.0 Uses and Limitations

One of the main objectives of the present test is to characterize leach behavior under conditions which minimize effects of laboratory artifacts, such as carbon dioxide, on the test results. The test provides for a maximum extent of elimination of contaminants by specifying a rigorous procedure of cleaning and pre-testing the leach vessels prior to use and by using tightly sealed, pressure-rated test vessels filled with nitrogen (or another controlled gas composition, as desired) and isolated from infiltration by acidic components of the atmosphere inside an outer controlled-environment container. In order to preserve the isolation of the leach vessels inside the outer container while ensuring sufficient mixing of the aqueous phase, the loaded containers are shaken thoroughly on a daily basis.

In order to ensure that all major species which determine the reactivity of the medium toward the solid are identified and taken into account, and that the relative contribution of species originating in the test environment is small, it is recommended to carry out cation-anion balance calculations on the results of the leachate analysis.

The test is intended to serve as a quick method of evaluating the relative performance of various waste-form compositions. It is not intended to be used in establishing

long-term predictions of the mechanism and rates of corrosion of particular waste forms. Other test procedures such as the pulsed-flow leach test method described in earlier documents should be used for the latter purpose.

5.0 Apparatus, Equipment, and Analytical Requirements

5.1 Leach Containers

Leach containers for routine tests shall be constructed of PFA Teflon. The volume of the leach container will be approximately 60 mL. The vessels should be designed to take internal pressures of at least 75 psi without leaking. Reuse of Teflon vessels is not recommended at the present time pending further studies. New Teflon leach containers shall be cleaned according to the following procedure:

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

(2) Rinse with 3 container volumes of high-purity H_2O (see paragraph 6.2).

(3) Boil in 6 M HNO_3 for 4 hours.

(4) Rinse with 3 container volumes of high-purity H_2O.

(5) Autoclave at 120°C for 1 hour in high-purity H_2O in a stainless steel pressurized container.

(6) Boil for 1 hour in high-purity H_2O in a stainless steel beaker.

(7) Soak for a minimum of 8 hours in high-purity H_2O in a polypropylene container at room temperature.

(8) Heat in a 200°C oven for 5 days.

(9) Boil for 1 hour in high-purity H_2O in a stainless steel beaker.

(10) Rinse with 3 container volumes of high-purity H_2O.

(11) Air-dry at room temperature.

(12) Fill the Teflon containers with 40 mL of high-purity carbonate-free water. Close the lid and leave in a 90°C oven for at least 24 hours.

(13) Measure the pH of the water.

(14) If the pH is less than 5.7 repeat the cleaning and testing procedure starting at Step (9).

Other configurations of leach vessels may be used in special cases. Test vessels similar in geometry to the Teflon vessels described above but made out of waste package materials, such as stainless steel, may be used to characterize the effects of such components.

The present method may be extended to longer periods either by attaching a septum cap to the lid of the vessel and withdrawing a small volume of leachate for analysis at the end of several immersion periods, or by using several different test vessels and using each one of them for a different test duration. The latter procedure, although it entails the use of the larger number of vessels, is recommended.

5.2 <u>Environmental Chamber</u>

The temperature of the leaching container within the oven shall be controllable to ± 1.0°C at the test temperature.

5.3 Volume Measurements

Measure leachant volumes gravimetrically or with properly calibrated pipets, burets, flasks, or cylinders accurate to within ± 5%.

5.5 Solution Analysis

Measure solute concentrations using equipment calibrated at standards traceable to NBS if possible. Determine and report precision and accuracy. Although analytical results should normally be accurate to within ± 10%, this may not be possible when concentrations in the solution approach detection limits. The detection limits for each analysis must accompany the reported result.

5.6 pH measurement

Measure the pH to an accuracy of ± 0.1 pH unit using a calibrated meter and commercial buffers.

5.7 Calibrations and Standards

Calibrate all instruments used in this test initially and periodically to minimize possible errors due to drift.

6.0 Leachant Preparation and Storage

6.1 General Chemicals

Chemicals used to prepare leachants other than de-ionized water should be of reagent grade or better, conforming to the specifications of the Committee of Analytical Reagents of the American Chemical Society.

6.2 High-Purity Water

The water referred to in this procedure should meet the following specifications:

Specific Resistance	>17.5 M ohm/cm at 25°C
Total dissolved inorganics	<0.1 mg/L (as $CaCO_3$)
Total dissolved organics	<1 mg/L
Particulate matter	<1 mg/L
pH	5.5 - 6.5

6.3 Preparation of Other Leachants

Other leachants, in particular leachants representing generic or site-specific, synthesized or actual groundwater compositions, shall be prepared according to paragraphs 6.3, 6.4 and 6.5 of the MCC-3S procedure.

6.4 Leachant Storage

Leachants must be renewed at least once every five months. High-purity water should not be stored for more than one month. Use polyethylene or polypropylene bottles with tight-fitting lids to store the leachants. Each bottle should be pre-cleaned at least 10 times with a total volume at least twice as large as its brim capacity of high-purity water.

7.0 Test Specimen Preparation

7.1 Characterization of Test Material

Document the fabrication method and fabrication conditions for the material from which the test specimens are prepared.

7.2 Pulverization of Waste-Form Material

Use a small number of blows by a heavy hammer to break the specimen, wrapped in a clean plastic bag, into a number of small fragments. Pulverize the fragments using a tungsten carbide mechanical grinder or manually with an agate, sapphire, or dense alumina mortar and pestle. The powder should be sieved to separate out the -100-mesh (149 microns) +200-mesh (74 microns) fraction by means of clean brass or stainless steel screens.

7.3 Specimen Handling

All handling of powders after preparation must be done with clean plastic or plastic coated spatulas and weighing paper. All powdered specimens must be stored in clean polyethylene or polypropylene containers in a desiccator until they are used.

8.0 Procedure

The leaching procedure for the individual specimens is given in section 8.2. The procedure consists of immersing quantities of pulverized specimen material in the leachant under conditions that are defined in section 8.3. See section 3.0 for safety precautions.

8.1 Quality Assurance

This test method must conform to all applicable quality assurance requirements of the laboratory performing the test.

8.2 Leaching an Individual Specimen

All tests should be carried out at least in duplicate according to the procedure given below. This procedure also applies to blanks, except that the specimen powder is omitted. The procedure described below applies mainly to de-ionized water at 90°C. The use of other leachants requires additional steps such as measuring the pH of the leachant prior to the test as detailed in the MCC-3S procedure.

The volume of leachant required is constrained by the volume of the leach container. The ratio of leachant volume to specimen mass shall be within ± 0.1 of 10 mL/g. The recommended volume and mass are 40 mL and 4 g, respectively; smaller amounts may be used if necessary but it is not recommended to use less than 1 g of specimen.

8.2.1 Weigh out the required amount of the pulverized specimen, prepared according to paragraph 7.2, and calculated to give, within ± 2%, the desired ratio of leachant volume to specimen mass according to the previous paragraph, using an analytical balance.

8.2.2 Use a leach vessel pre-cleaned according to paragraph 5.1. It is recommended to rinse the leachant container with the leachant immediately before use. Clean a 1000-mL stainless steel beaker by rinsing it three times with high-purity water (see paragraph 6.2) and boiling in it a volume equal to its brim capacity of high-purity water. Repeat this step two more times. Place 300-600 mL of the

leachant in the stainless steel beaker and insert a clean plastic tubing to introduce a nitrogen stream from a high-purity nitrogen cylinder through guard tubes of Ascarite® and Drierite®, sequentially. Cover the beaker with clean aluminum foil. Gently boil the leachant for a period of at least 10 minutes while bubbling with nitrogen at a rate of approximately 20 mL/min. (Note: In the cases of leachants specified to contain dissolved carbon dioxide or carbonates, e.g. in the cases of carbonated ground-water compositions, omit the boiling and nitrogen-bubbling steps.)

8.2.3 Place the weighed amount of the pulverized specimen in the clean leach vessel. Add the required volume of the boiling, nitrogen-bubbled leachant. (In the case of carbonated leachants, add the corresponding volume of the untreated pure leachant.) Mix well to wet the powdered glass and remove entrapped air. Displace the air in the upper part of the container with a stream of nitrogen. Seal the container quickly and tightly with a clean cover. Tighten the cover, shake thoroughly for 2 minutes, and immediately place the container in a tightly sealed, well lubricated glass or metal desiccator, which contains a large dish filled with Ascarite®. (Ascarite® should be used whenever the test is carried out with high-purity water as the standard leachant or with any other leachant which requires the absence of carbonate and carbon

dioxide; whenever a leachant is specified to contain carbonates, do not introduce Ascarite®.) It is recommended to weigh the loaded leach vessel before placing it in the desiccator. After placing all leach vessels in the desiccator, pass through it a stream of purified nitrogen for at least 10 minutes before finally sealing it. Place the desiccator with a set of leach vessels as soon as possible in the environmental chamber, which has been pre-heated to the test temperature (90°C).

8.2.4 Measure the testing period from the time the desiccator with the leach vessels is placed in the environmental chamber to the time that it is removed from the environmental chamber. Record the date and time.

8.2.5 Tighten the cover again after 1 day.

8.2.6 Shake the loaded desiccator thoroughly every day.

8.2.7 Control the testing period to within 2% or 4 hours, whichever is less. At the conclusion of the testing period, record the date and time, and remove the desiccator from the environmental chamber. Containers must not be shaken on sampling day. Remove the loaded leach containers from the desiccator.

8.2.8 Determine the mass loss of the leach container. If it is larger than 10%, repeat the test starting with a new specimen at step 8.1.

[8.2.9 In the case of the optional test procedure where the leach vessel is fitted with a septum cap, remove 4 mL of leachate from the vessel by means of a plastic syringe for pH and chemical analysis. Return the loaded container into the desiccator and return the desiccator to the environmental chamber to continue the test.]

8.2.10 Carefully open the leach container. Remove 3 mL of the leachate by means of a clean, disposable plastic pipetting device. Transfer this aliquot into a 4-mL plastic cup placed in a water bath at room temperature. Measure the pH with a calibrated pH meter, record the pH, and discard the aliquot.

8.2.11 Remove another 1 mL of the leachate by means of a clean, disposable plastic pipetting device and dilute at once with high-purity water (see paragraph 6.2) to a total volume of 25 mL or 21 mL for chemical analysis.

8.2.12 Store the dilute leachate for analysis in a capped clean polystyrene vial and analyze the leachate as soon as possible (definitely within one day) for all the radioactive species (e.g, U and Th) or their substitutes, all major matrix elements (e.g., Si and Al) and for all the highly leachable species (e.g., boron and the alkalis). It is also highly recommended to analyze the leachate for all the anions present in significant quantities and to use the results of the analysis to

ascertain a satisfactory agreement (within ± 10%) between the total concentrations of cations and anions, respectively. In this case the analysis should be repeated if a satisfactory ionic balance is not demonstrated.

8.3 Test Conditions

The reference test temperature is 90°C. The reference leachant is high-purity water (see paragraph 6.2). The reference powder mass and leachant volume are 4 g and 40 mL, respectively. The reference leach vessel is a PRA Teflon container with a cover without openings. Each specimen is tested at least in duplicate, preferably in triplicate, and each set of test vessels is accompanied by two leachant blanks. Optional test conditions are described in Section 10.0.

9.0 Procedure for Preparing the Blanks

9.1 Follow the procedure given in Section ? for the leachant and leachant container. Omit the steps that relate to the waste-form specimen.

9.2 Use two blanks with each set of specimens.

10.0 Additional, Optional Test Conditions

10.1 These conditions are not mandatory but provide further information on the leach behavior of the waste form under highly interactive conditions.

10.2 The use of test periods other than 7 days, for instance 28, 56, 112 and 365 days. (It is recommended to perform each test in a separate vessel; consecutive sampling using a vessel with a septum cap is described in paragraph 8.2.8.)

10.3 The use of leachants other than high-purity water, for instance synthetic silicate water leachants or actual ground water.

10.4 Tests on waste-form specimens in the presence of solid materials representing other components of the waste package (canister, overpack/backfill, rock). In particular. leach vessels made out of stainless steel may be substituted for the standard Teflon vessels.

11.0 Calculations

11.1 Use of Blank Data

Correct the leachate concentrations by subtracting the corresponding blank concentrations. Use the average of the blank data. Blanks are used principally to check if sources of contamination are present.

11.2 Ionic Composition and Ionic Balance Calculations

In the case that both the cation and anion composition of the leachate is determined, as recommended in paragraph 8.2.12, the agreement between the total calculated concentrations of cations and anions, respectively, should be verified to be within ± 10%. Otherwise the analysis should be repeated.

11.3 Concentration of Individual Elements in the Leachate

Optionally, calculate the molar concentration of elements in the leachate using the procedure given in section 9.3 of the MCC-3S procedure.

11.4 Normalized Leach Rates

Calculate the normalized leach rate, $(LR)_i$, in $g \cdot m^{-2} \cdot d^{-1}$, based on the leaching of element i, according to the following equation:

$$(LR)_i = \frac{C_i}{\sigma_i \, (S/V)}$$

where C_i = concentration of element i in the leachate in g/m^3 (or mg/L) corrected by subtracting the corresponding average blank.

σ_i = mass fraction of element i in the specimen when the experiment started.

S/V = ratio of the surface area (S) of the solid to the leachant volume (V) under the conditions of the experiment, in m^{-1}, where S is expressed in m^2 and V in m^3.

12.0 Precision and Accuracy

Follow the data control procedures detailed in section 10.0 of the MCC-3S procedure.

13.0 Reports

The format for reports should follow the procedure detailed in section 11.0 of the MCCO-3S procedure.

APPENDIX D

POTENTIAL CANISTER CLOSURE METHODS

The WVDP is currently investigating methods for the canister closure weld that can limit the leak tightness to the specified value. This includes the type of welders at the DOE's EMAD Facility in Nevada and the welder developed for closing the remote handled (RH) TRU Container.[33] One of the EMAD welders is a gas tungsten arc welder, and the other is a plasma arc welder. Both use a fixture that attaches to the top of the canister and the weld arc rotates around it. The RH TRU welder is a remotely operated gas metal arc welder. During welding, the canister is rotated via a turntable. The welder includes a rework cutter in case weld repairs are needed. Any welder selected for the final closure of the West Valley canister will require some modification. For example, the RH TRU container is made of carbon steel and has a diameter of 66 cm.

The selection of the final closure process will be made prior to shipout to the repository. The deferral of the selection results from insufficient present resources available for weld development, installation, and operation. The WVDP is a remedial action project, not a production facility. Vitrification will be a single one and a half year campaign, Therefore, the amount of money that is spent on equipment is minimized. The time at which the final closure is made will not influence its acceptability. By delaying the final closure the WVDP will be able to assess welders available at that time. When a final closure method is selected, the supporting data will be made available.

APPENDIX E

GAS ACCUMULATION IN A CANISTERED WASTE FORM UP TO THE GLASS TRANSITION TEMPERATURE.

Specification 3.2 GAS SPECIFICATION[a]

(portion of specification dealing with gas evolution due to heating of waste form)

REQUIREMENT

"The producer....shall document in the WQR the quantities and compositions of any gasses that might accumulate inside the canister after the canister has been subjected to temperatures up to the transition temperature of Specification 1.4(a)"

RESPONSE

No significant amount of gas will accumulate inside the canister after closure as a result of the canister being heated up to the glass transition temperature.

After manufacture, volatility from waste glass is a factor only in accident analyses. Waste glass manufacturing temperatures are several hundred degrees above the maximum design storage temperatures. This assures that any volatiles that might pressurize the canisters during storage have been removed (Mendel 1978).

Numerous volatility studies, related to accident performance [primarily fires during production or transport (Rusin 1980)] have been conducted at the Pacific Northwest Laboratory (PNL). These studies have used an apparatus in which air (either dry or moist) flows past a heated sample and then past a water cooled "cold finger" where condensibles are collected for chemical analysis. The heated sample is suspended from a balance, thus enabling the weight of the sample to be continuously monitored (Gray 1976). Typical volatiles from waste glasses at high temperatures (800 to 1200°C) include the fission products Rb, Mo, Te, and Cs, and the glass formers B, Na, and K (Gray 1976, Gray 1980, Mendel 1981, Ross 1978, Wald 1980); Cs has been found to be the most volatile. Other studies have also confirmed these behaviors (Hastie 1983, Terai 1976).

Although Cs and other elements are released, the vapor pressures of the compounds that these elements will form [e.g., oxides, hydroxides, or alkali borates (Terai 1976)] are extremely low at the glass transition temperature referred to in the specification. For example, alkali metal (Cs, Na, K) hydroxides have vapor pressures of 1 mm Hg (0.0013 atm.) or less at temperatures between 700 and 750°C (Weast 1980). The vapor pressure of MoO_3 is 1 mm Hg at 734°C (Weast 1980). Therefore, the amounts of gas that will be present at 700 to 750°C, due to volatility, will not be significant. At the glass transition temperature of WV-205 (approximately 500°C) the vapor pressures of the compounds that will incorporate the volatilized elements will be even lower.

a) Specification is quoted from the April 1986 Draft for Concurrence of the Waste Acceptance Preliminary Specifications for the West Valley Demonstration Project High Level Waste Form.

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APPENDIX F

POTENTIAL CANISTER DECONTAMINATION TECHNIQUES

The WVDP is investigating several canister decontamination techniques including rinsing in a tank containing nitric acid and Ce^{+4}, spraying with high pressure water, frit blasting, and electropolishing. The technique using Ce^{+4} involves placing the canister in a tank containing a solution of nitric acid and Ce^{+4} for about an hour and then rinsing the canister in another tank with water. In the high pressure water method, water flowing through a spraying nozzle fixture is used to rinse the canister. In frit blasting, glass frit is added to the water which erodes the canister surface. Electropolishing uses the canister as an anode suspended in a solution of phosphoric acid; material is electrochemically removed. The criteria that will be used to select a decontamination process will include the ability to meet the required limits, amount of and ease of treating secondary waste (because much of the canister decontamination will take place after vitrification, the solutions cannot be recycled), amount of facility space required, and cost.

One of these techniques may be used prior to placing the canisters in the on-site storage facility. Because this facility will be a decontaminated cell in the fuel reprocessing plant with possibly some residual contamination, and failed vitrification process equipment may be stored there which will spread contamination, the canisters may need to be decontaminated again to meet the contamination limits. This final decontamination technique probably will not be selected until after vitrification when the design of the shipout facility and supporting equipment is defined.