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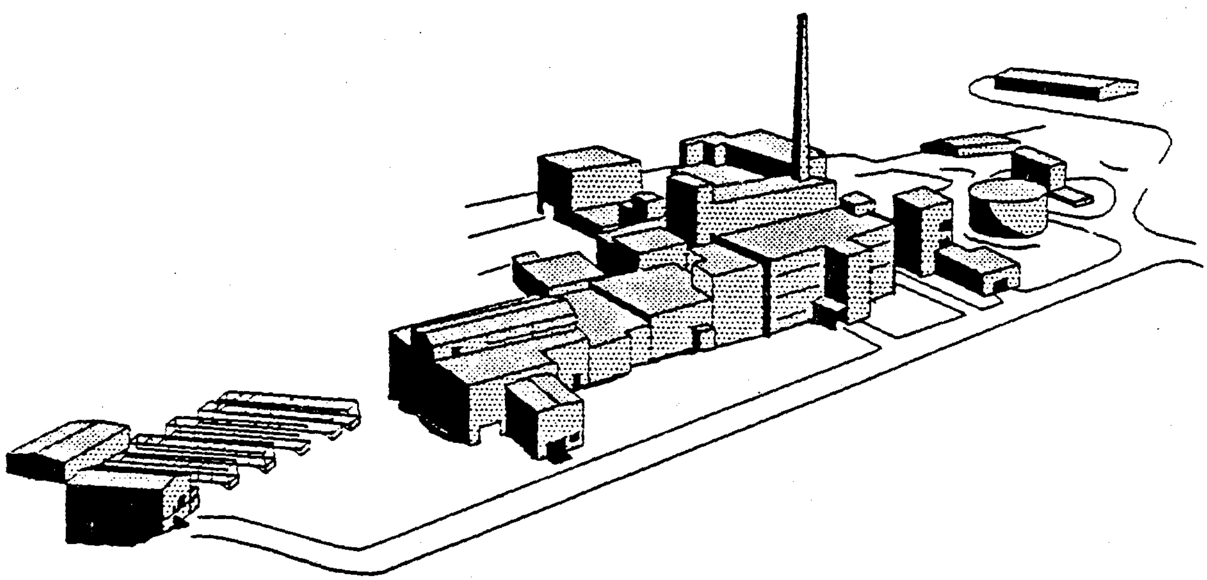
Waste Form Compliance Plan for the West Valley Demonstration Project High-Level Waste Form



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West Valley Demonstration Project

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

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WVNS RECORD OF REVISION

DOCUMENT

If there are changes to the controlled document, the revision number increases by one. Indicate changes by one of the following:

- Placing a vertical black line in the margin adjacent to sentence or paragraph that was revised.
- Placing the words MAJOR CHANGE REVISION at the beginning of the text.
- Placing either FC#> or PC#> (whichever applies) in the left-hand margin at the beginning of the paragraph or section where the field/page change has been made AND placing a vertical black line in the margin adjacent to the actual change.
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Example:

The vertical line in the margin indicates a change. |

FC1> The FC#> in the margin along with the vertical line (redline) indicates a change. |

Rev. No.	Description of Changes	Revision On Page(s)	Dated
0	Original Issue	All	4/28/88
1	Per ECN #2910	All	04/89
2	Per ECN #3720	All	06/90
3	Per ECN #4805 Complete Rewrite	All	12/23/91
4	Per ECN #5611	v,53,54	10/09/92
5	Per ECN #5984	All	06/22/93
6	Per ECN #6529 General Revision	All	07/08/93
7	General Revision Document formerly issued as WVNS-WCP-001.	All	01/13/94
8	Revised per final WA-TRG comments; Letter CD:95:0003	All	08/02/94
9	Revised per OCRWM comments, Letter WD:95:0011 and CD:95:0016	All	02/10/95

WVNS RECORD OF REVISION CONTINUATION FORM

Rev. No.	Description of Changes	Revision On Page(s)	Dated
10	Correct number of sludge samples taken for radionuclide analysis (reference letters CD:95:0025 and DW:95:0893).	21	08/02/96
11	Changes in verification of cold chemical composition, slurry acceptance process, and deletion of reference to Process Control Program (PCP) to implement lessons learned during first year of hot operations.	14,28	07/17/97
12	Revised text to conform with the second revision of the EM-WAPS and lessons learned during initial operation of Vitrification Facility (reference letter CD:98:0014).	iii,vi,1,22,31, 32,35,38-41,44 45,48-54,56,57,59,60 61,63-71,73-77, AD-1-1 - AD-1-6	04/03/98

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

INTRODUCTION

As part of the waste acceptance process, the U. S. Department of Energy's Office of Environmental Restoration and Waste Management has developed Waste Acceptance Product Specifications (WAPS) for vitrified high level waste forms (U.S. DOE, 1996(a)). These WAPS define the technical requirements and documentation requirements that must be met before the producer's high-level vitrified waste form can be accepted into the Civilian Radioactive Waste Management System.

The WAPS, which are based on the system-level requirements defined in the Waste Acceptance System Requirements Document or WASRD (U.S. DOE, 1996(b)), are divided into five sections dealing with the borosilicate glass waste form, the canister, the canistered waste form, quality assurance, and documentation and other requirements. The West Valley Demonstration Project (WVDP) is required to document its compliance with the WAPS in the Waste Form Compliance Plan (WCP), the Waste Form Qualification Report (WQR), the Production Records and in the Storage and Shipping Records.

This document, the Waste Form Compliance Plan (WCP) for the West Valley Demonstration Project, reviews the nature of the high-level wastes at West Valley, and the vitrification process that will be used to immobilize that waste and describes the methods and strategies by which the WVDP will demonstrate compliance with each specification in the WAPS. The WCP will form the basis for the more detailed WQR wherein test results and analyses will be used to confirm WVDP's strategies for producing an acceptable product. The Production Records and the Storage and Shipping Records will document the contents and characteristics of specific individual canistered waste forms and provide direct evidence for acceptance into the Civilian Radioactive Waste Management System (CRWMS).

West Valley Waste

The West Valley Nuclear Services Company, Inc. (WVNS), operator of the West Valley Demonstration Project (WVDP), has been charged with the responsibility for solidifying two million liters of high-level radioactive waste (HLW). These wastes, which remain from the former commercial nuclear fuel reprocessing plant at West Valley, New York, consist of a basic sodium hydroxide treated sludge and supernatant liquid originally traceable to processing fuel via a PUREX flowsheet and approximately 55,000 liters of acidic solution produced by processing fuel via a THOREX flowsheet. The HLW will be combined with non-radioactive components and vitrification process recycle streams to form a single waste type. This vitrification process should yield about 500 metric tons of borosilicate glass which will be poured into about 300 stainless steel canisters for eventual disposal in the federal waste repository.

The high-level waste currently stored at the WVDP was generated between 1966 and 1972 by the Nuclear Fuel Services (NFS) Corporation. Most of the waste was produced by reprocessing spent uranium fuel from various nuclear reactors using the PUREX process. This waste was then basified by adding sodium hydroxide to render it non-aggressive for storage in a carbon steel tank. The waste has now separated into a precipitated hydroxide sludge which has settled to the bottom of the tank and a supernatant salt solution. A small fraction of the WVDP waste resulted from processing a batch of thorium matrix fuel from the Indian Point I reactor using the THOREX process. This acidic waste is stored in a stainless steel tank. Estimates of the chemical composition and radionuclide contents of these wastes are given in Tables 5-9 in Sections 1.1 and 1.2.

There are a total of four storage tanks at the WVDP. Carbon steel Tank 8D-2 contains the PUREX waste, with 8D-1 as a spare (at present, cesium loaded zeolite from the supernatant decontamination process treatment is temporarily being stored in Tank 8D-1 as discussed in the following section). Stainless steel Tank 8D-4 contains the THOREX waste, with 8D-3 as its spare.

Waste Pre-Treatment Program

Figures 1 and 2 are flow diagrams of the waste pre-treatment and vitrification processes to be used at WVDP. As indicated in these figures, a number of chemical processing steps will be taken to prepare the HLW for vitrification and to minimize the final volume of the HLW glass. Ion-exchange columns, loaded with zeolite IE-96*, are used to remove cesium from the PUREX supernatant. After the PUREX supernatant has been treated, the precipitated sludge will be washed to remove soluble sulfates and interstitial supernatant. These wash solutions will also be decontaminated using the zeolite ion-exchange process. Both the decontaminated supernatant and the sludge wash solutions will be processed, solidified as cement, and disposed of as low-level, radioactive waste. These solutions are not solidified as part of the HLW Vitrification process.

After the liquids have been processed, the THOREX waste will be transferred to tank 8D-2, neutralized and mixed with the PUREX sludge. The zeolite temporarily being stored in 8D-1 will also be moved to 8D-2, combined with the THOREX and PUREX wastes and mixed to make one large, relatively homogeneous mixture. The estimated oxide composition of each of these waste streams is listed in Table 1. The mixture of wastes provides the basis for the final glass composition, which is expected to be relatively constant over the life of the project.

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* Ionsieve IE-96 zeolite, UOP Corporation.

Process Overview

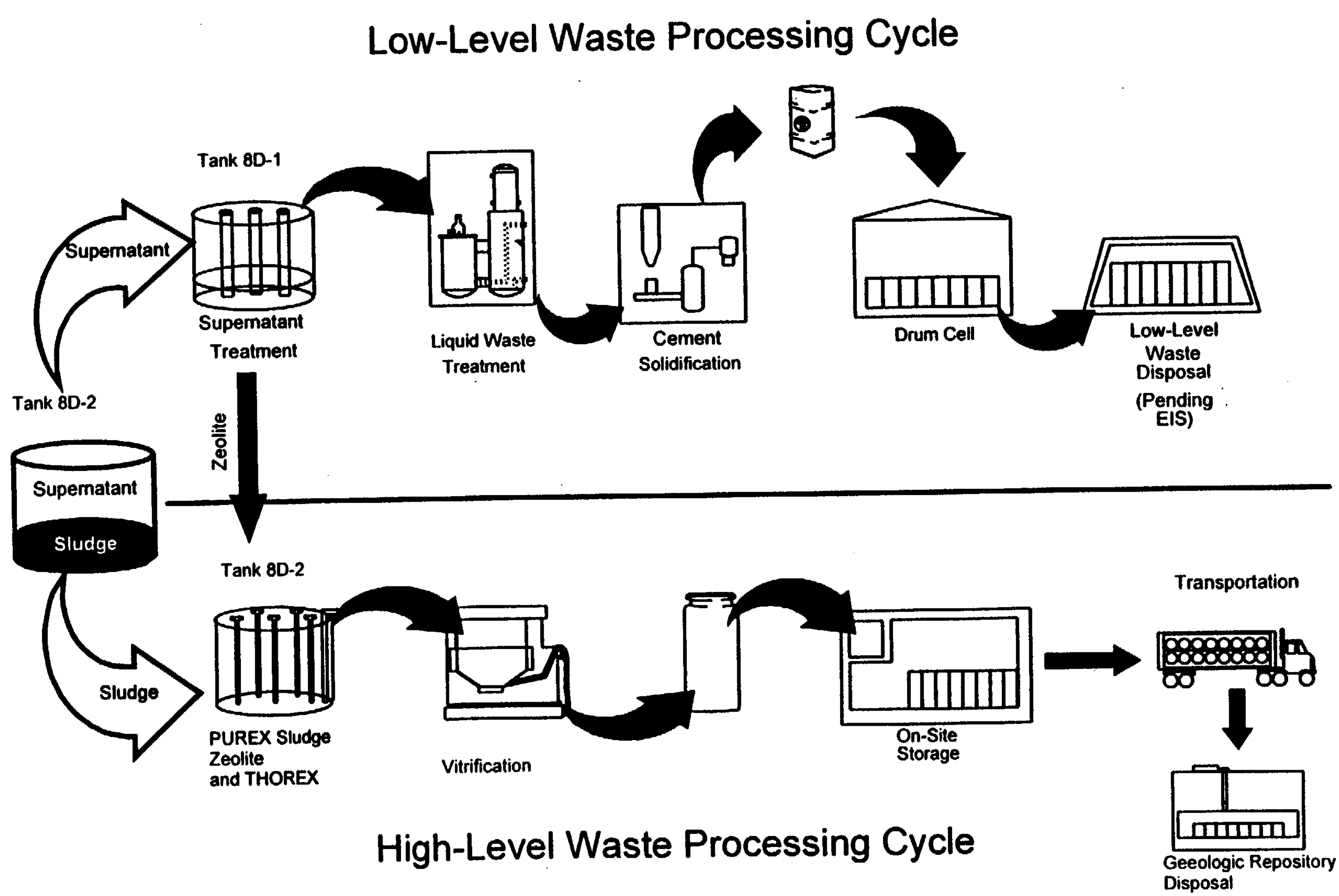

Figure 1
Simplified WVDP Waste Processing Cycle (Schematic)

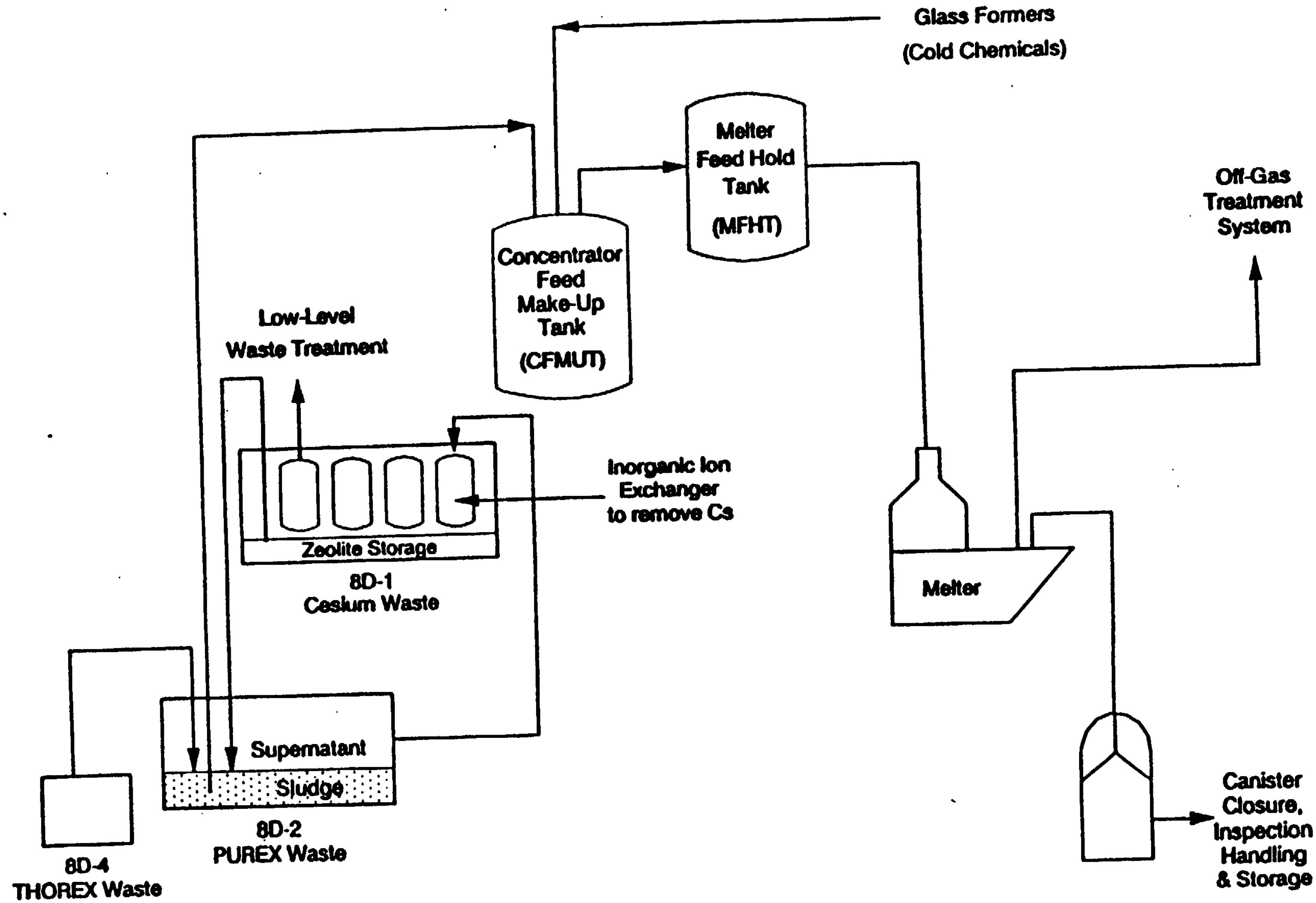
Glass Formers
(Cold Chemicals)
Melter
Feed Hold
Tank
(MFHT)
Concentrator
Feed
Make-Up
Tank
(CFMUT)
Off-Gas
Treatment
System
Low-Level
Waste Treatment
Inorganic Ion
Exchanger
to remove Cs
Zeolite Storage
8D-1
Cesium Waste
Melter
Supernatant
Sludge
8D-2
PUREX Waste
8D-4
THOREX Waste
Canister
Closure,
Inspection
Handling
& Storage

FIGURE 2

(Although other process wastes are expected to be added during vitrification to Tank 8D-2, they are minimal and sufficiently close to the overall waste composition so that they can be ignored. For instance, the waste liquid from the submerged bed scrubber (SBS) will be periodically flushed to Tank 8D-2. This material is relatively small in volume and is made up of particulate matter which has been scrubbed from the melter off-gas. Similarly, for waste generated in the analytical laboratory during sample analysis, the composition will essentially be the same as the wastes sampled from the concentrator feed make-up tank (CFMT).)

Vitrification

After mixing in 8D-2, the waste will be transferred as a slurry to the concentrator feed make-up tank (CFMT). This is the first vessel in the vitrification system. Here the waste is heated to concentrate the slurry (evaporate excess water) and samples are taken for chemical analysis. This analysis determines the amount of each glass-forming chemical to be added to the waste. (The recipe and details on feed material make up are discussed thoroughly in Section 1.1.) The major glass-forming materials, as listed in Table 1, are added as oxides, hydroxides, carbonates, and nitrates. In addition to the glass compounds, other materials such as sucrose are mixed in the Cold Chemical Main Mix Tank prior to being added to the waste in the CFMT. Sucrose is a reducing agent which aids in processing the feed in the melter by preventing glass foaming reactions that can disrupt glass production. The amount of glass-forming material and sucrose to be added to the HLW in the CFMT is determined by analyzing the waste composition and the volume of waste to be processed. The nominal waste oxides concentration in the waste glass will be about 40 per cent by weight. One slurry batch in the CFMT is expected to produce approximately three canisters of waste glass. After mixing in the glass-forming materials, another chemical analysis is performed to verify that the waste/glass former slurry composition is correct. The slurry batch is then transferred to the melter feed hold tank (MFHT). These slurry transfers were examined in the full-scale, nonradioactive Functional and Checkout Testing of Systems (FACTS) testing program*. As the slurry is transferred to the MFHT, it is added to the heel remaining in that tank. As noted above, all materials transferred to the MFHT will have been tested to assure the correct composition. Therefore, the newly prepared slurry batch will be combined with the heel from the previously approved slurry batch. (The heel can range up to 25 to 35 percent of the tank volume.) This slurry blending procedure is expected to dampen the small chemical compositional variations between the individual CFMT batches, further improving the consistency of the glass product.

The slurry will then be continually metered from the MFHT to the slurry-fed, ceramic-lined melter (SFCM) where it is introduced on top of the molten glass pool during glass production. In the melter, the slurry dries and forms a "cold cap" at the glass surface. The volatiles, water vapor and decomposition gases released from the cold cap are collected and processed in an off-gas treatment system. A cross-section of the melter is shown in Figure 3. Three electrodes supply energy directly to the melt, using the electrical resistance of the molten glass to provide the heat for melting. The cold cap melts from its bottom to form the borosilicate waste glass. A glass pool of approximately 850L will be continuously maintained in the melter.

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* The WVDP FACTS program (1984 - 1989) was designed to perform verification tests of full scale components/systems and establish operating parameters necessary for radioactive operations.

TABLE 1. NOMINAL OXIDE CONTENT OF THE WVDP GLASS
AS A FUNCTION OF SOURCE
(kilograms)

	PUREX*	THOREX	ZEOLITE	GLASS-FORMING ADDITIVES	FINAL GLASS	GLASS, %
Al_2O_3	4.1E+03	1.0E+03	9.8E+03	1.4E+04	2.9E+04	6.0E+00
B_2O_3	3.0E+01	2.7E+02	0.0E+00	6.1E+04	6.2E+04	1.3E+01
CaO	1.7E+03	1.0E+01	4.6E+02	1.3E+02	2.3E+03	4.8E-01
Fe_2O_3	5.3E+04	2.8E+03	2.0E+03	0.0E+00	5.8E+04	1.2E+01
K_2O	0.0E+00	1.2E+02	1.9E+04	4.4E+03	2.4E+04	5.0E+00
Li_2O	4.0E+00	0.0E+00	0.0E+00	1.8E+04	1.8E+04	3.7E+00
MgO	4.0E+02	1.0E+01	4.4E+02	3.4E+03	4.3E+03	8.9E-01
MnO	2.7E+03	4.0E+01	0.0E+00	1.2E+03	3.9E+03	8.2E-01
Na_2O	7.0E+03	2.4E+02	1.2E+04	2.0E+04	3.8E+04	8.0E+00
P_2O_5	5.7E+03	5.0E+00	0.0E+00	4.5E+01	5.8E+03	1.2E+00
SiO_2	7.1E+03	6.0E+01	3.8E+04	1.5E+05	2.0E+05	4.1E+01
ThO_2	0.0E+00	1.7E+04	0.0E+00	0.0E+00	1.7E+04	3.6E+00
TiO_2	1.0E+00	0.0E+00	3.3E+02	3.5E+03	3.8E+03	8.0E-01
UO_3	3.0E+03	4.2E+00	0.0E+00	0.0E+00	3.0E+03	6.3E-01
ZrO_2	1.2E+02	0.0E+00	0.0E+00	6.2E+03	6.3E+03	1.3E+00
OTHER+	7.3E+03	6.0E+00	7.4E+02	1.2E+02	8.1E+03	1.7E+00
TOTALS	92,155	21,565	82,770	281,995	483,500	100

* Washed PUREX sludge
\+ Oxide components that individually, constitute less than 0.5 percent of the glass

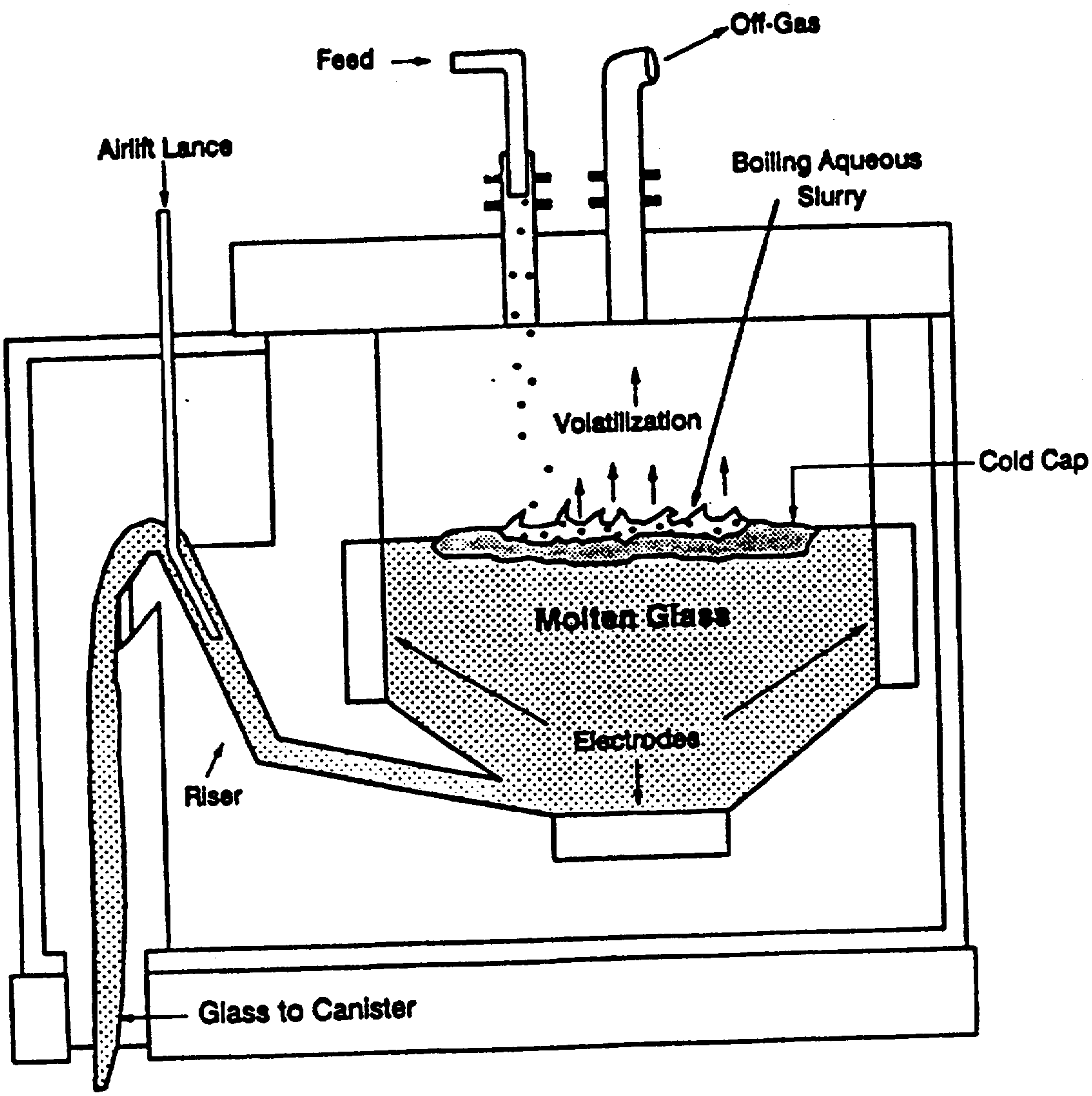

Figure 3

The WVDP Slurry Fed Ceramic Melt

Glass pouring will be initiated by an air-lifting process. In this process, a small amount of air (<30L/minute) is bubbled into the column of glass in the riser leading to the pour spout. This air effectively reduces the apparent specific gravity of the glass column. The difference in density between the glass in the riser and the glass in the main melt pool gives rise to a hydrostatic head that causes the glass in the riser to flow up to a point where it can fall into the canister. The small amount of air in the glass disengages from the glass stream as it flows into the canister.

Canister Handling

Four canisters are held on a turntable positioned beneath the melter. The canister turntable rotates through four positions. After a canister is filled, it will remain on the turntable for (typically) seven to ten days. During this time, the canister openings will remain covered by the turntable.

Canister filling will be monitored for process control purposes by a remote infrared thermal imaging system. As the canister fills with molten glass, the level will be inferred by measuring the discontinuity in thermal emission from the canister surface.

The primary canister cooling mode is radiant and convective heat transfer to the Vitrification Cell environment. Carefully controlled canister cooling experiments have shown that the centerline temperature of the glass will be below the glass transition temperature within about 30 hours after filling.

Several days after filling, the canister will be removed from the turntable and transferred to the lid closure welding station located within the Vitrification Cell. At this time, glass fill height will be measured. Prior to canister closure welding, glass shard samples will be remotely removed from the top surface of the filled canister for chemical analysis. (Shard samples are small chunks of glass that detach from the top surface of the glass as a result of thermal stresses generated during cooling of the canistered waste form. Shard samples are taken from every canister, but only a certain number of them will be analyzed. This will be discussed further in Section 1.3.) Remote shard sampling and canister closure welding will be performed as soon as practicable following removal of the canister from the turntable; it is anticipated that canister closure would be completed within about two days following canister removal from the turntable.

After closure, the external surfaces of the filled canister will be cleaned using the Ce^{+4} decontamination process (Bray, 1988) and the canister will then be transferred to the on-site storage facility.

Document Description

This Waste Form Compliance Plan (WCP) addresses the requirements from the Waste Acceptance Product Specifications (WAPS) for Vitrified High-Level Waste Forms (U.S. DOE, 1993(a)) issued by the Office of Environmental Restoration and Waste Management. If the WAPS are significantly revised, WVDP will consult with DOE to determine the extent of revision necessary for the WCP and WQR.

In this document, each specification from the WAPS appears in boldfaced, italic type. This is followed by a brief summary of the WVDP's Compliance Strategy and the more detailed description of the Implementation of that strategy. Finally, a summary of the required Documentation for each specification is provided. Addendum 1 provides a glossary defining terms and acronyms used in this report.

The specification numbering in the WAPS, the WCP and the subsequent WQR sections has a one to one correspondence. For example, a citation in the WCP document under Specification 2.3 stating that more detail will be provided in the WQR means that this information appears in WQR Section 2.3.

1.0 WASTE FORM SPECIFICATIONS

1.1 Chemical Specification

The waste form is borosilicate waste glass.

1.1.1 Chemical Composition Projections

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

Compliance Strategy

The waste materials stored at the WVDP are generally well-known and well characterized. There are extensive records of the operations of NFS regarding the types of fuels that were processed and the process flow sheets. (No new wastes are expected to be added to the current inventory.) Additionally, a number of analyses of both the sludge and supernatant have been performed over the years. The WVDP has taken advantage of this information in designing the glass composition and vitrification process for waste immobilization.

The five-year series of FACTS runs has provided the WVDP with considerable information regarding the projection of glass composition based on knowledge of feed composition. The combination of well-characterized waste materials and the various studies conducted during FACTS, demonstrates the ability to predict the final glass composition. These studies will be reported and analyzed in the WQR. Because of the available information described above, the WVDP will vitrify a single waste type containing all of the HLW constituents into a (single) target glass composition.

Based upon prototypic, full-scale tests, bounding canistered glass cooling rates will be determined. Glasses of the target composition and others within the potential target glass selection region (see Tables 2 and 3) will be fabricated and heat-treated using this limiting cooling rate profile. These heat-treated glasses will be characterized to determine the quantity and composition of the crystalline phases present.

Implementation

The WVDP will vitrify a single, high-level waste type containing all of the HLW constituents, producing a glass with one target composition. The target glass formula will be selected from the range indicated in Table 2. This range is much greater than the actual process variations exhibited during the FACTS program (typically <15 relative percent for the species present at concentrations exceeding 1 wt% in the final glass). Table 2 contains the region in composition space of glasses examined by the West Valley programs which exhibit good processibility characteristics and comply with Specification 1.3. The target composition selected from this range will meet Specification 1.3 requirements and have a viscosity between 20 and 100 poise at 1100°C. The target glass is expected to be similar to the composition listed in Table 3.

The anticipated crystalline phases present in the product glass will be estimated using laboratory generated glasses exposed to heat-treatments bounding the full-scale system. This strategy enables production of simulated waste glasses in the FACTS program (i.e., substitutions made for uranium and thorium for personnel protection) where full-scale canister cooling behavior can be measured. Then, laboratory glasses containing uranium, thorium, noble metals, etc., can be exposed to the thermal history measured in the full-scale canisters to generate the crystalline phase data.

Laboratory generated radioactive glass of the target composition exposed to the bounding heat-treatment to characterize its crystallization behavior will be analyzed. Crystalline phase data collected from both the laboratory and FACTS produced glasses and the data supporting the use of laboratory produced glasses will be presented in the WQR. Justification for comparing these two different glasses will also be provided in the WQR.

The WQR will also discuss the effects of decay heat generation and glass production rates on the glass cooling history. The decay heating effects are anticipated to be minimal due to the low heat generation expected for West Valley canisters. The effects of the glass filling rate for a canister on the non-vitreous (i.e., crystalline) phases in the product glass will also be addressed in the WQR. This assessment will determine the sensitivity of the canistered glass cooling rates to filling rates, periodic filling cycles, and the anticipated glass production rates for the West Valley Vitrification System.

The cooling data for the canistered glass has been collected during a dedicated, full-scale FACTS test using instrumented canisters. The temperature data were collected with an array of thermocouples located approximately 56 cm, 120 cm, and 182 cm above the canister base. At each of the three axial locations, thermocouples were positioned at the following approximate radial points:

1 cm from the canister wall

5 cm from the canister wall

10 cm from the canister wall

25 cm from the canister wall (5 cm from the canister center line)

TABLE 2

West Valley Potential Target Glass Selection Region

Oxide	Weight Percent Lower Bound	Weight Percent Upper Bound
Al_2O_3	3.5	8.5
B_2O_3	8.8	16.9
BaO + CaO + MgO	0.5	2.5
Fe_2O_3	9.0	15.0
K_2O	3.5	6.5
Li_2O	2.7	4.7
MnO	0.1	2.0
Na_2O	6.0	10.0
P_2O_5	0.0	4.0
SiO_2	37.5	44.5
ThO_2	1.0	5.0
TiO_2	0.1	1.5
UO_3	0.1	2.0
ZrO_2	0.5	2.0
Others*	0.5	6.0

* Others (Ce_2O_3, CoO, Cr_2O_3, Cs_2O, CuO, La_2O_3, MoO_3, Nd_2O_3, NiO, PdO, Pr_6O_{11}, Rh_2O_3, RuO_2, Sm_2O_3, SO_3, SrO, Y_2O_3, ZnO)

TABLE 3

Estimated West Valley Target Glass Composition

Oxide	Weight Percent
Al_2O_3	6.00
B_2O_3	12.89
BaO	0.16
CaO	0.48
Ce_2O_3	0.31
CoO	0.02
Cr_2O_3	0.14
Cs_2O	0.08
CuO	0.03
Fe_2O_3	12.02
K_2O	5.00
La_2O_3	0.04
Li_2O	3.71
MgO	0.89
MnO	0.82
MoO_3	0.04
Na_2O	8.00
Nd_2O_3	0.14
NiO	0.25
P_2O_5	1.20
PdO	0.03
Pr_6O_{11}	0.04
Rh_2O_3	0.02
RuO_2	0.08
SO_3	0.23
SiO_2	40.98
Sm_2O_3	0.03
SrO	0.02
ThO_2	3.56
TiO_2	0.80
UO_3	0.63
Y_2O_3	0.02
ZnO	0.02
ZrO_2	1.32
TOTAL	100.00

These temperature data have been used as the bounding thermal history for the laboratory generated glasses. Glass samples have also been characterized from near the thermocouple locations in the instrumented canisters to establish the crystalline phases present in production glasses. Comparisons with glasses heat-treated in the laboratory to simulate the cooling history will also be made and discussed in the WQR.

The heat-treated glass samples have been characterized for non-vitreous (i.e., crystalline) phases by energy dispersive x-ray spectroscopy, x-ray diffraction, and petrography. A weighted average of the percentage of crystalline phases was calculated to estimate the overall percentage expected in a canistered waste form. The weighted average was calculated based upon the measured crystal content for a given cooling rate at a given radial position and the corresponding volume at the radial position. The minimum detectable crystal size by optical petrographic techniques is about 5 microns. The minimum detectable quantity of crystals is about 0.1 volume percent. Further breakdown into volume percent of specific crystalline phases was per- formed by estimation using a scanning electron microscope. The expected total volumetric quantity of non-vitreous material and estimated uncertainties will be reported in the WQR.

A discussion of the effect of the non-vitreous phases on the product consistency requirements of Specification 1.3 will be included in WQR Section 1.3.

Documentation

The WQR will contain the target glass composition, an estimate of the range of glass composition expected from WVDP, and an estimate of the composition and amount of the crystalline phases to be anticipated in the canistered glass.

1.1.2 Chemical Composition During Production

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

Compliance Strategy

Documentation of the production glass composition will be obtained from the chemical analyses of shards removed from the top of the canistered glass. The WQR will document that shards taken from the top of the filled canister are representative of the entire canister.

The FACTS cold testing data demonstrating the slurry feed control methodology and the resulting glass product compositions will be included in the WQR. The glass sample analyses will be reported in the Production Records.

Implementation

The WVDP will vitrify a single, high-level waste type containing all of the HLW constituents, producing a glass with one target composition as given in Table 3. The waste slurry preparation cycle planned to yield the consistent glass composition is outlined below:

> The three West Valley high-level wastes (the washed PUREX sludge, THOREX, and cesium loaded zeolite) will have been combined in Tank 8D-2 prior to vitrification. The pumps installed in 8D-2 for the PUREX sludge washing campaigns will be used to mix the combined wastes, minimizing the potential for inhomogeneities.
>
> The blended wastes will be transferred in batches into the Vitrification Facility for solidification. The typical HLW slurry batch preparation cycle is as follows:

- Waste slurry from Tank 8D-2, along with various other vitrification process recycle streams (e.g., the submerged bed scrubber condensate), are combined with the heel from the previous batch in the Concentrator Feed Makeup Tank (CFMT) as shown in Figure 2. This waste slurry mixture is sampled and then concentrated through evaporation in the CFMT to remove excess water. The CFMT contains a stirrer which continuously agitates the mixture. Studies conducted during the FACTS runs demonstrated that the mixture remains homogeneous during agitation.

- Samples of the combined CFMT waste are chemically analyzed. These analyses are used to determine the chemical additions required to shim the CFMT contents to the target melter slurry feed composition. These additions are prepared in the cold chemical facility. The chemicals added will be either glass formers or non-radioactive isotopes of waste species. The waste chemical species would be added if their concentrations were below the domain of the PCT model described in WQR Section 1.3 in the combined CFMT waste slurry. The chemical composition of these cold chemical additions will be independently confirmed prior to their being pumped as a slurry to the CFMT.

- After the cold chemical additions have been mixed with the waste slurry, additional samples are obtained. The chemical composition of these samples will be tested to confirm both the attainment of the desired slurry formulation and mass balance closure (i.e., CFMT waste slurry sample analysis + cold chemical additions = the analytical results from the slurry taken after the wastes and glass former additions have been blended together). (The feed batch acceptance strategy will require each CFMT batch to pass two tests. These are: 1) the predicted PCT value (plus total error) must be less than the EA glass and, 2) the 95% confidence interval of the mean must be within the domain of the PCT model described in WQR Section 1.3 and $-11 \le$ the $\sum$ index (see Section 1.3) ≤ 5. This strategy will be

described in greater detail in the WQR and the Vitrification Process Chemistry System Description (WVNS-SD-63P). If the combined waste and glass former slurry samples fail this test, additional sampling or chemical addition operations will be performed and the acceptance test repeated. Only after the combined waste and glass former slurry sample has successfully been shown to meet the requirement will the slurry batch be transferred to the MFHT for vitrification processing.

As discussed above, the HLW slurries will be adjusted to the domain of the PCT model composition via chemical additions at the CFMT. This strategy will enable the WVDP to produce a consistent glass product over the operating campaign. After the slurry is vitrified, samples of the glass will be removed as glass shards from each production canister; as discussed in Section 1.3.1, shards from approximately 30 randomly selected canisters will actually be chemically analyzed. Chemical analysis of the CFMT waste slurry acceptance samples will be recorded in the WVDP in-process records; the analysis of the glass shards will be reported in the Production Records. (Analyses of the individual shard samples will be reported with the identification of the canisters which were sampled).

The CFMT slurry samples will be obtained from a recirculating sampling loop. The slurry will be pumped to the sampling station where the specimen will be obtained using the sampling valve system employed at DWPF (Caplan, 1987). The samples will be analyzed by the methods described in Table 4.

The glass samples will be obtained by removing shards from the top of the filled canisters. The anticipated shard sampling device will be a vacuum wand to remove the glass samples just prior to canister closure. It will be shown in the WQR that the shard samples are equivalent to samples taken from anywhere in the canister.

FACTS included fully integrated melter runs. The melter runs had durations ranging up to 45 days. Simulated waste, including zeolites, based on the most recent chemical analyses of waste tank samples (e.g., see Tables 5 to 8 from Rykken, 1984, 1985, 1986), with Zr and other appropriate elements substituting for the radioactive elements, were used during these tests. Glass formers were in the form expected during radioactive vitrification. During the FACTS melter test runs, the physical and chemical properties of the waste slurry simulant, glass formers, melter feed, and glass shard samples were analyzed. Methods used for compositional analysis of samples included inductively coupled plasma atomic emission spectroscopy and atomic absorption spectrophotometry. The critical melter control parameters that were monitored during these runs were feed composition and melt temperature. The glass composition was monitored and controlled through chemical additions. These additions were based on the waste slurry analyses. The glass melt temperatures were measured with thermocouples and recorded according to operating procedures. Other details of this testing are provided by Eisenstatt and Routt (1988).

Documentation

The WQR will discuss the methods used for analyzing the elements present in the production glass in concentrations greater than 0.5 wt%. An estimate of the uncertainties and the detailed compliance strategy which identifies the specific canisters from which shard samples will be analyzed will also be in the WQR. The Production Records will contain all glass shard chemical analyses (for all elements >0.5 wt%). Individual shard analyses will be a part of the Production Records; the overall composition of the "waste type" comprised of about 300 canisters will be reported in the Production Records as an average of the individual shard analyses.

TABLE 4

Chemical Analysis Method Planned For The
Reportable Waste Glass Elements

Element	Planned Analytical Method*
Al	ICP-AES
B	ICP-AES
Ca	ICP-AES
Fe	ICP-AES
K	AA or ICP-AES
Li	ICP-AES
Mg	ICP-AES
Mn	ICP-AES
Na	ICP-AES
P	ICP-AES
Si	ICP-AES
Th	ICP-AES
Ti	ICP-AES
U	ICP-AES
Zr	ICP-AES

* ICP-AES - Inductively Coupled Plasma-Atomic Emission Spectroscopy;
AA - Atomic Absorption Spectrophotometry.

TABLE 5

Estimated PUREX Insoluble Solids
(Tank 8D-2) Chemical Composition

Component		Mass (Kg)
$Fe(OH)_3$		6.6E+04
$FePO_4$		6.4E+03
$Al(OH)_3$		5.9E+03
AlF_3		5.8E+02
MnO_2		2.7E+03
$CaCO_3$		3.4E+03
$UO_2(OH)_2$		3.1E+03
$Ni(OH)_2$		9.4E+02
SiO_2		7.1E+03
$Zr(OH)_4$*		1.6E+02
$MgCO_3$		5.1E+02
$Cu(OH)_2$		3.8E+02
$Zn(OH)_2$		1.9E+02
$Cr(OH)_3$		1.5E+02
$Hg(OH)_2$		2.3E+01
Fission Products**		
Rare Earth Hydroxides		1.5E+03
Other Hydroxides		1.5E+03
Sulfates		4.8E+02
Transuranics		
NpO_2		3.5E+01
PuO_2		3.7E+01
Am_2O_3		2.7E+01
Cm_2O_3		4.0E-01
	TOTAL	1.0E+05

* Excludes fission product zirconium.
** See Table 6 for breakdown.

TABLE 6

Estimated PUREX Insoluble
Solids (Tank 8D-2), Fission Products

Rare Earths	Mass (Kg)
$Nd(OH)_3$	6.3E+02
$Ce(OH)_3$	3.8E+02
$La(OH)_3$	1.7E+02
$Pr(OH)_3$	1.7E+02
$Sm(OH)_3$	1.4E+02
$Eu(OH)_3$	8.0E+00
$Gd(OH)_3$	2.0E+00
$Tb(OH)_3$	3.0E-01
$Dy(OH)_3$	2.0E-01
$Pm(OH)_3$	1.5E+00
Other Components	
$Zr(OH)_4$	8.1E+02
$Ru(OH)_4$	4.6E+02
$BaSO_4$	3.0E+02
$SrSO_4$	1.8E+02
$Y(OH)_3$	1.0E+02
$Rh(OH)_4$	7.9E+01
$Pd(OH)_2$	3.4E+01
$Sn(OH)_4$	3.0E+00
$Cd(OH)_2$	2.0E+00
$Sb(OH)_3$	1.0E+00
AgOH	1.0E+00
$In(OH)_3$	3.0E-01
$Ge(OH)_3$	1.7E+00

TABLE 7

Estimated PUREX
Supernatant (Tank 8D-2) Chemical Composition*

Compound		Mass (Kg)
$NaNO_3$		6.0E+05
$NaNO_2$		3.1E+05
Na_2SO_4		7.6E+04
$NaHCO_3$		4.3E+04
KNO_3		3.6E+04
Na_2CO_3		2.5E+04
NaOH		1.8E+04
K_2CrO_4		5.1E+03
NaCl		4.7E+03
Na_3PO_4		3.8E+03
Na_2MoO_4		6.9E+02
Na_3BO_3		6.0E+02
$CsNO_3$		5.3E+02
NaF		5.0E+02
$Sn(NO_3)_4$		2.5E+02
$Na_2U_2O_7$		2.3E+02
$Si(NO_3)_4$		2.3E+02
$NaTcO_4$		1.8E+02
$RbNO_3$		1.2E+02
Na_2TeO_4		8.2E+01
AlF_3		7.7E+01
$Fe(NO_3)_3$		4.3E+01
Na_2SeO_4		1.5E+01
$LiNO_3$		1.4E+01
H_2CO_3		9.0E+00
$Cu(NO_3)_2$		6.0E+00
$Sr(NO_3)_2$		4.0E+00
$Mg(NO_3)_2$		2.0E+00
H_2O		1.7E+06
	TOTAL	2.8E+06

* Prior to supernatant processing with UOP Ionsieve IE-96 zeolite.

TABLE 8

Estimated THOREX Waste (Tank 8D-4)
Chemical Composition

Compound	Mass (Kg)	Compound	Mass (Kg)
$Th(NO_3)_4$	3.1E+04	$Zr(NO_3)_4$	1.2E+01
$Fe(NO_3)_3$	8.5E+03	Na_3PO_4	1.2E+01
$Al(NO_3)_3$	4.2E+03	$NaTcO_4$	1.1E+01
HNO_3	2.8E+03	$Y(NO_3)_4$	1.4E+01
$Cr(NO_3)_3$	1.9E+03	$Rh(NO_3)_4$	1.1E+01
$Ni(NO_3)_2$	7.9E+02	$Zn(NO_3)_4$	1.0E+01
H_3BO_3	4.8E+02	$Pd(NO_3)_4$	8.0E+00
$NaNO_3$	2.3E+02	$UO_2(NO_3)_2$	6.0E+00
Na_2SO_4	1.8E+02	$RbNO_3$	6.0E+00
KNO_3	1.9E+02	Na_2TeO_4	5.0E+00
Na_2SiO_3	1.3E+02	$Co(NO_3)_2$	3.0E+00
K_2MnO_4	9.8E+01	Na_2SeO_4	1.0E+00
$Mg(NO_3)_2$	5.7E+01	NaF	1.0E+00
Na_2MoO_4	5.4E+01	$Eu(NO_3)_3$	1.0E+00
NaCl	5.0E+01	$Np(NO_3)_4$	9.0E-01
$Nd(NO_3)_3$	7.3E+01	$Sn(NO_3)_3$	7.0E-01
$Ce(NO_3)_3$	4.3E+01	$Cu(NO_3)_2$	8.0E-01
$Ru(No_3)_4$	4.2E+01	$Pa(NO_3)_4$	7.0E-01
ZrO_2*	3.5E+01	$Pu(NO_3)_4$	7.0E-01
$Ca(NO_3)_2$	3.0E+01	$Gd(NO_3)_3$	4.0E-01
$CsNO_3$	2.8E+01	$Cd(NO_3)_2$	3.0E-01
$Ba(NO_3)_2$	2.7E+01	$X(NO_3)_4$**	2.0E-01
$La(NO_3)_3$	2.2E+01	$Sb(NO_3)_3$	1.0E-01
$Pr(NO_3)_3$	2.1E+01	$AgNO_3$	8.0E-01
$Sr(NO_3)_2$	1.6E+01	$In(NO_3)_3$	4.0E-01
$Sm(NO_3)_3$	1.4E+01	$Pm(NO_3)_2$	1.0E-01
		H_2O	3.4E+04
		TOTAL	8.5E+04

* Insolubles Assumed to be ZrO_2
** Am, Cm, and Miscellaneous Actinides

1.2 Radionuclide Inventory Specification

The producer shall report the inventory of radionuclides (in Curies) that have half-lives longer than 10 years and that are, or will be, present in concentrations greater than 0.05 percent of the total radioactive inventory for each waste type, indexed to the years 2015 and 3115.

1.2.1 Radionuclide Inventory Projections

The producer shall provide in the WQR estimates of the total quantities of individual radionuclides to be shipped to the repository, for each waste type. The producer shall also report the upper limit of these radionuclides for any canistered waste form, and an average calculated radionuclide inventory per canister for each waste type. The method to be used to obtain the required data shall be described by the producer in the WCP. The data shall be provided in the WQR. Radionuclide inventory estimates not available for reporting in the initial WQR shall be included in an addendum to the WQR.

Compliance Strategy

The estimated total quantities of individual radionuclides will be based upon an ongoing waste characterization program for WVDP HLW and calculations based on ORIGEN2 (Radiation Shielding Information Center (a), 1987) simulation runs on fuel campaign data. The average estimated inventory in the canisters will be based upon filling canisters nominally 85 percent full and will account for radionuclide ingrowth.

Upper limits per canister will be based on a canister 100% full and upper limits of error derived from analysis of the original HLW production data at West Valley and actual HLW sample analysis.

Implementation

The estimated total quantities of individual radionuclides are based on an ongoing high-level waste characterization program being performed at West Valley (Rykken et al., 1984, 1985, Rykken, 1986) and are shown in Table 9. Simulations run on the ORIGEN2 computer code have been made using available data for each of the separate irradiated fuel campaigns from which the waste was generated. Plutonium and uranium recovery data were used to separate the waste from the usable fuel components, and processing dates were used to input decay times. Summation of all the campaigns then yielded total waste tank contents. There was good agreement between analytical results from waste tank samples and output from the ORIGEN2 run (WVNS-DP-024, 1994). The radiochemical uncertainties will be based on sample analyses. This ORIGEN2 output will be formally qualified, per the West Valley Quality Assurance Program, using corroborating radiochemical waste sample analyses, prior to use in the WQR.

The sludge in Tank 8D-2 has been sampled by using a core sampler that penetrated to the bottom of the sludge layer insuring that the core was representative of a vertical cross-section of the sludge layer. Core samples were taken through each of the four Tank 8D-2 risers and have been analyzed. Supernatant has also been sampled using a jet sampler. Sampling results will be reported in the WQR.

TABLE 9

ESTIMATED RADIONUCLIDE CONTENT
WEST VALLEY WASTES, 1987 BASELINE

NUCLIDE	PUREX SUPERNATANT Ci	PUREX SLUDGE Ci	THOREX Ci	TOTAL Ci	NUCLIDE	PUREX SUPERNATANT Ci	PUREX SLUDGE Ci	THOREX Ci	TOTAL Ci
3-H	9.74E+01	0.00E+00	1.74E+00	9.91E+01	223-Fr	0.00E+00	1.26E-05	1.04E-01	1.04E-01
14-C	1.37E+02	0.00E+00	1.30E-01	1.37E+02	223-Ra	0.00E+00	9.14E-04	7.52E+00	7.52E+00
55-Fe	0.00E+00	1.00E+03	5.63E+02	1.56E+03	224-Ra	0.00E+00	1.19E-01	9.76E+00	9.88E+00
60-Co	0.00E+00	4.70E+00	1.14E+03	1.14E+03	225-Ra	0.00E+00	6.61E-06	2.07E-01	2.07E-01
59-Ni	0.00E+00	8.56E+01	2.03E+01	1.06E+02	228-Ra	0.00E+00	4.81E-09	1.48E+00	1.48E+00
63-Ni	8.89E+02	5.34E+03	2.51E+03	8.74E+03	225-Ac	0.00E+00	6.61E-06	2.07E-01	2.07E-01
79-Se	5.68E+01	0.00E+00	3.35E+00	6.02E+01	227-Ac	0.00E+00	9.14E-04	7.52E+00	7.52E+00
90-Sr	2.89E+03	6.74E+06	4.54E+05	7.20E+06	228-Ac	0.00E+00	4.81E-09	1.48E+00	1.48E+00
90-Y	2.89E+03	6.74E+06	4.54E+05	7.20E+06	227-Th	0.00E+00	9.01E-04	7.42E+00	7.42E+00
93-Zr	2.56E-01	2.56E+02	1.62E+01	2.72E+02	228-Th	0.00E+00	1.19E-01	9.76E+00	9.88E+00
93m-Nb	1.59E-01	1.59E+02	1.02E+01	1.69E+02	229-Th	0.00E+00	6.61E-06	2.07E-01	2.07E-01
99-Tc	1.60E+03	0.00E+00	1.04E+02	1.70E+03	230-Th	0.00E+00	1.45E-02	4.38E-02	5.83E-02
106-Ru	1.10E-01	1.10E+02	6.24E-01	1.11E+02	231-Th	6.41E-03	8.94E-02	5.17E-03	1.01E-01
106-Rh	1.10E-01	1.10E+02	6.24E-01	1.11E+02	232-Th	0.00E+00	5.87E-09	1.64E+00	1.64E+00
107-Pd	1.09E-02	1.09E+01	1.14E-01	1.10E+01	234-Th	5.71E-02	7.97E-01	7.11E-05	8.54E-01
113m-Cd	2.41E+00	2.41E+03	3.75E+01	2.45E+03	231-Pa	0.00E+00	2.86E-04	1.52E+01	1.52E+01
121m-Sn	1.76E-02	1.76E+01	5.99E-01	1.82E+01	233-Pa	0.00E+00	2.30E+01	3.02E-01	2.33E+01
126-Sn	1.01E-01	1.01E+02	3.11E+00	1.04E+02	234a-Pa	5.71E-02	7.97E-01	7.11E-05	8.54E-01
125-Sb	4.90E+01	1.51E+04	2.89E+02	1.54E+04	232-U	3.13E-01	4.36E+00	2.74E+00	7.41E+00
126-Sb	1.42E-02	1.42E+01	4.35E-01	1.46E+01	233-U	4.98E-01	6.94E+00	2.09E+00	9.53E+00
126m-Sb	1.01E-01	1.01E+02	3.11E+00	1.04E+02	234-U	2.80E-01	3.90E+00	2.17E-01	4.40E+00
125m-Te	1.20E+01	3.70E+03	7.08E+01	3.78E+03	235-U	6.41E-03	8.94E-02	5.17E-03	1.01E-01
129-I	2.10E-01	0.00E+00	1.80E-01	3.90E-01	236-U	1.91E-02	2.67E-01	9.80E-03	2.96E-01
134-Cs	1.39E+04	0.00E+00	3.10E+02	1.42E+04	238-U	5.71E-02	7.97E-01	7.11E-05	8.54E-01
135-Cs	1.56E+02	0.00E+00	5.47E+00	1.61E+02	236-Np	0.00E+00	9.35E+00	1.23E-01	9.47E+00
137-Cs	7.26E+06	0.00E+00	4.75E+05	7.74E+06	237-Np	0.00E+00	2.30E+01	3.02E-01	2.33E+01
137m-Ba	6.87E+06	0.00E+00	4.49E+05	7.32E+06	239-Np	0.00E+00	3.43E+02	4.49E+00	3.47E+02
144-Ce	2.09E-05	9.21E+00	1.39E-01	9.35E+00	236-Pu	1.36E-02	8.24E-01	1.09E-02	8.49E-01
144-Pr	2.09E-05	9.21E+00	1.39E-01	9.35E+00	238-Pu	1.27E+02	8.00E+03	4.80E+02	8.61E+03
146-Pm	4.77E-02	1.53E+01	5.07E-01	1.59E+01	239-Pu	2.54E+01	1.61E+03	1.54E+01	1.65E+03
147-Pm	5.71E+02	1.85E+05	9.11E+03	1.95E+05	240-Pu	1.87E+01	1.18E+03	8.09E+00	1.21E+03

TABLE 9

ESTIMATED RADIONUCLIDE CONTENT
WEST VALLEY WASTES, 1987 BASELINE (CONT.)

NUCLIDE	PUREX SUPERNATANT Ci	PUREX SLUDGE Ci	THOREX Ci	TOTAL Ci
151-Sm	5.03E-01	8.15E+04	4.78E+03	8.63E+04
152-Eu	4.57E-02	3.77E+02	4.82E+01	4.25E+02
154-Eu	1.44E+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
212-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
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

NUCLIDE	PUREX SUPERNATANT Ci	PUREX SLUDGE Ci	THOREX Ci	TOTAL Ci
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	2.93E+02	6.76E+00	2.99E+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	5.95E+00	2.49E+02
243-Cm	0.00E+00	1.44E+02	2.34E-01	1.44E+02
244-Cm	0.00E+00	8.56E+03	1.37E+01	8.57E+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

Projections of the estimated total quantities of individual radionuclides based on inventories (estimated from waste characterization work) expected to be shipped from the WVDP and the corresponding individual canister inventory will be reported in the WQR. The average expected inventory in a canister will be based upon a canister 85 percent full (see Section 3.5). The lower bound will be based upon a canister 80 percent full and the lower uncertainty estimates for the total expected inventory in the waste. The upper bound will be based upon a canister 100 percent full and the upper estimate for the total expected inventory in the waste.

In order to ensure that the radionuclide reporting requirements are satisfied, radionuclide decay and ingrowth calculations for the isotope estimates in the canister will then be performed for the years 2015 and 3115.

Documentation

The WQR will provide estimates of the total quantities of individual radionuclides expected to be shipped from the WVDP and the projected upper limit and average radionuclide inventory in each canister. The uncertainties of these estimates will also be reported.

1.2.2 Radionuclide Inventory During Production

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

Compliance Strategy

WVNS plans to meet the WAPS requirement solely with glass shards removed from the top of the canistered glass, measuring the inventory of key radionuclides and relating these values to the other required radionuclide values through the use of scaling factors derived from the WVDP waste characterization program. Sampling frequency, precision, and accuracy will be based upon the results of qualification testing. The glass shards will be demonstrated to be representative of the canister glass in the WQR.

The WQR will include a list of all radionuclides to be shipped with half-lives longer than 10 years and that are or will be present in concentrations greater than 0.01 percent of the total radioactive inventory for each waste type indexed to the years 2015 and 3115.

Implementation

A sampling approach similar to the one used to provide chemical composition during waste vitrification will be used to provide key radionuclide inventory in the canistered waste forms: glass shards from a statistical random sampling of approximately 30 glass canisters will be analyzed for key radionuclides and related to the inventory in the canistered waste form as discussed in Section 1.1.2. The sampling frequency and the expected precision and accuracy will be reported in the WQR. The estimated radionuclide inventory was decayed 1100 years to determine which radionuclides have half-lives of more than 10 years and will comprise more than 0.05% of total waste as measured in curies. These radionuclides are listed in Table 10.

In the WQR, radionuclides down to 0.01% will be identified to allow for the uncertainty in the estimated inventory calculations and to more confidently assure that all radionuclides down to 0.05% are identified. Inventory values for those radionuclides not directly analyzed will be obtained by using scaling factors. The scaling factors are ratios between the radionuclide isotopes that are measured and others that must be reported. These scaling factors will be based on analyses of waste samples removed after THOREX neutralization and waste homogenization.

Three different methods are being planned to estimate the level of reportable radionuclides in the WVDP canisters. This is due to the fact that some radionuclides can be readily compared with Sr-90 and Cs-137 and others cannot. For instance, since most plutonium and uranium isotopes were recovered as products from chemical separations, shipping records and waste measurement values are used for these radionuclides.

The simplest method will be used for Sr-90 and Cs-137. These two radionuclides with their short-lived daughters will represent over 98% of the total activity in the glass (circa 1996). Therefore, they can be measured directly. Shards from a subset of the entire set of canisters will be analyzed for these radionuclides and the means and standard deviations reported. Based on numerical modeling of the WVDP flowsheet, including simulated analyses, the mean and standard deviations for both these species are expected to be < 15,000 ± 3500 μCi/gm of glass (circa 1996). ORIGEN-S, or anOther verified computer code, will be used to predict the Sr-90 and Cs-137 radionuclide concentrations for the years 2015 and 3115 reported.

A second method is required for other reportable radionuclides including: Ni-59, Ni-63, Np-236, Np-237, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Am-242m, and Am-243. Based upon analyses of waste samples removed after THOREX neutralization and waste homogenization, the ratio of these radionuclides will be computed relative to Sr-90 in the 8D-2 waste mixture. From these ratios (and their uncertainties) and the measured Sr-90 levels in the glass-filled canisters (and its uncertainty), the levels and uncertainties of this set of radionuclides will be computed. Since these radionuclides are present in much smaller levels compared to Sr-90, the uncertainties for these radionuclides are expected to be over 100% relative.

A similar approach will be used for Tc-99. During waste processing prior to vitrification, most if not all of the Tc-99 will be contained in the LLW cement waste form. After the waste processing has been completed and before the start of vitrification, the ratio of Tc-99 relative to Cs-137 will be measured. Based on this ratio and the measurement of Cs-137 in the glass-filled canisters, the level of Tc-99 and its uncertainty in the canisters will be computed. The projected level of Tc-99 that must be characterized in the waste after all LLW processing is completed is <0.1 μCi per ml of solution. Since Tc-99 is present in much smaller levels compared to Cs-137 and is close to the detection limit, the uncertainty in the ratio is expected to be over 100% relative.

This same type of approach is to be used for Cs-135. Using Cs-137 as the key measurement, the level and uncertainty of Cs-135 will be computed based upon the analyses of waste samples removed after THOREX neutralization and waste homogenization.

TABLE 10

Possible Radionuclides In the Vitrification Feed
That Specification 1.2 Requires To Be Reported*

Radionuclide	Radionuclide
Ni-59	U-233
Ni-63	U-234
Sr-90	Np-236
Zr-93	Np-237
Nb-93m	Pu-238
Tc-99	Pu-239
Pd-107	Pu-240
Sn-126	Pu-241
Cs-135	Am-241
Cs-137	Am-242m
Sm-151	Am-243
Ac-227	
Pa-231	

* Half life >10 years, concentration >0.05 percent of total radioactive inventory up to the year 3115.

A third method will be required for all the other reportable radionuclides (i.e., Zr-93, Nb-93m, Pd-107, Sn-126, Sm-151, Ac-227, Pa-231, U-233, and U-234). The estimated inventories for these isotopes will be used to establish the level of these radionuclides relative to Sr-90. No uncertainty values can be quoted for these radionuclides since the precision and accuracy of the computer code from which they are derived is not unequivocally known. However, the relatively low activity level of these radionuclides coupled with the extreme difficulty in separation and counting make the use of the reactor burn-up calculations mandatory.

Total canister radionuclide inventory for production canisters will be determined by applying the concentrations determined from the above analyses to the actual measured glass content (i.e., fill height) of each canister.

Measured uncertainties for radionuclides sampled and analyzed will be reported in the WQR. Uncertainties for other radionuclides will be determined using error propagation to combine uncertainties in measured values and ratios.

Documentation

The WQR will detail all reportable radionuclides with half-lives greater than 10 years and that are or will be present in concentrations greater than 0.01% indexed to years 2015 and 3115, the methods to be used to determine the radionuclide inventory during production and the precision and accuracy of the methods used. The means and the standard deviations will be computed and reported on a total production campaign basis.

The estimate of the radionuclide content for the canistered waste forms will be based on the analyses of the shards from approximately ten percent (i.e., ~30) of the canisters. In the Production Records, the mean value, and its uncertainty, will be reported as the radionuclide content for each of the canistered waste forms, adjusted for the glass content (fill height) of that individual canister. The values reported in the Production Records will either be measured or calculated values, depending on the particular radionuclide.

1.3 Specification for Product Consistency

The producer shall demonstrate control of waste form production by comparing, either directly or indirectly, production samples to the Environmental Assessment (EA) benchmark glass (U.S. DOE, 1982). The producer shall describe the method for demonstrating compliance in the WCP and shall provide verification in the Production Records. The producer shall demonstrate the ability to comply with the specification in the WQR.

1.3.1 Acceptance Criterion

The consistency of the waste form shall be demonstrated using the Product Consistency Test (PCT) (Jantzen, 1992(a)). For acceptance, the mean concentrations of lithium, sodium and boron in the leachate, after normalizing for the concentrations in the glass, shall each be less than those of the benchmark glass described in the Environmental Assessment for selection of the DWPF waste form (Jantzen, 1992(b)). The measured or projected mean PCT results for lithium, sodium and boron shall be provided in the Production Records. The producer shall define the statistical significance of the reported data in the WQR. One acceptable method of demonstrating that the acceptance criterion is met, would be to ensure that the mean PCT results for each waste type are at least two standard deviations below the mean PCT results of the EA glass.

1.3.2 Method of Compliance

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

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

Compliance Strategy

The WVDP will predict PCT results, based on an analysis of production glass samples, and compare these predictions to measured EA glass data. The PCT predictions will be based on a regression model correlating measured PCT results to glass composition. For the radioactive production glass, the reported PCT predictions will be formulated from chemical analyses of canistered glass shard samples. The predicted normalized PCT release for B, Li, and Na will be compared to measurements from the benchmark EA glass to demonstrate compliance with this specification.

Control over the production of the waste form will be demonstrated by close attention to the slurry feed composition. Feed slurry composition data and the projected glass composition will be translated into predicted PCT response information by use of an empirical model developed for that purpose. Before releasing any feed batch for processing, its composition will be verified as to its ability to produce acceptable glass as defined by the specification. Details will be found in system description WVNS-SD-63P, "VF Process Chemistry".

Implementation

The PCT release information for WVDP production glass will be predicted using a mathematical model for comparison to the EA standard. The proposed statistical methodology for the comparison of the West Valley glass product to the EA glass includes:

1. establishing the PCT leachate concentrations (B, Li, and Na) for the EA glass,

2. characterizing the composition of the glass population produced (including sampling uncertainty, analytic uncertainty, and batch-to-batch variation),

3. developing a reliable correlation (i.e. a model) relating the measured composition of laboratory prepared "cold" samples (no fission products but containing uranium and thorium) and laboratory measured PCT results for B, Li, and Na,

4. using the model to predict PCT results from the production glass composition,

5. determining the uncertainty associated with the model, and

6. showing that the glass population's high predicted leachate concentration, including model and composition uncertainties, is less than the PCT results for the EA standard.

Each of these topics will be developed below.

Establishing the PCT Performance of the EA Glass

The PCT leachate concentrations for B, Li, and Na will be measured for the EA glass at two national laboratories (Savannah River and Pacific Northwest) at a minimum. The reported results from these tests will be analyzed, generating a mean normalized leachate concentration value for each of the required species. These values will form the EA glass baseline for comparison to the production glass PCT predictions to demonstrate compliance with this specification.

Preliminary results have been published by Savannah River (Jantzen, et al., 1993). These data are being used to assess the performance of early West Valley PCT models.

Production Glass Composition Determination

Approximately 300 canisters of waste glass will be produced during the radioactive glass production campaign. Glass shards will be analyzed from a statistical random sampling of approximately 30 glass canisters prior to final weld closure. These shard analyses will be used to qualify the glass population by demonstrating that the production glass PCT results are less than the EA glass as outlined below. The method of using a random number table to do the random sampling process will be specified in the WQR, as well as the enumeration of exactly which canisters were chosen.

These shard samples, representing the glass population, will be chemically analyzed as described in Section 1.1.2. For each of the three PCT releases (B, Li, and Na) an index value, Σ, will be formed using a weighted sum of key glass oxides as described in the next section. The index will be calculated for each of the approximately 30 glass shards and then they will be evaluated to confirm normality of the index value population. (Normality is required for forming the 95/95 tolerance interval to be used below.) The number of canisters which need to be sampled is based primarily on the need to have a sufficient number of samples so that after accounting for model and composition uncertainties the bulk of the glass produced can be declared to be

better than EA glass with high confidence. Secondarily, the number of canisters to be sampled must be sufficient to use the test for normality chosen. Thirty is the rough estimate of the number which may be required. The WQR will specify both the test for normality used and the exact number of canisters required to be sampled.

The mean and standard deviations of the indices will be calculated and a two-sided, 95/95 tolerance interval constructed for the indices population. At this point, there is 95% confidence that 95% of the Σ values from the population lie within the tolerance interval.

PCT Model Development

The model being developed has the form

$$\hat{log}[\lambda] = b_0 + b_1\Sigma + b_2\Sigma^2$$

where λ represents the normalized PCT leachate concentration of B or Li or Na.

The Σ variable, or index, represents a weighted sum of the key elements in the glass which are known to affect its leachability. From a glass science perspective, the elements which would be expected to impact the glass durability are the network formers (Al, Fe, Si, Th, and Zr) and the network modifiers (B, K, Li, and Na). The weight percentages of the oxides of these elements are combined as

$$\sum = B - 0.3Fe - 3.5\frac{Si+Al+Zr+Th}{Na+K+Li}$$

several other combinations of these elements have been tested for the Σ equation, but this form has produced the best results. The b_n coefficients will be determined using a second order, least squares regression analysis of PCT data for glasses within a range of the target glass composition.

This general modeling approach has been successfully demonstrated at the Catholic University of America (CUA). They have reported good results in using their model to distinguish between excellent and marginal PCT performing glasses (Pegg, et al., 1988). Based both on the CUA modeling results and the firm basis in glass science, the decision was made to pursue the development of this model form rather than using only statistical methods to develop the predictor variable combinations.

More specifically, the prediction equation is of the form

$$\hat{Y} = b_0 + b_1\Sigma + b_2\Sigma^2$$

where Y = log[λ]. This prediction equation results from a least squares fit of n data points (Σ_i, Σ_i^2, log[λ_i]), i=1,...,n, to the model $\mathbf{Y} = \mathbf{X}\beta + \epsilon$, where

$$\boldsymbol{Y} = \begin{bmatrix} \log[\lambda_1] \\ \log[\lambda_2] \\ . \\ . \\ . \\ \log[\lambda_n] \end{bmatrix} \quad \boldsymbol{X} = \begin{bmatrix} 1\ \Sigma_1\ \Sigma_1^2 \\ 1\ \Sigma_2\ \Sigma_2^2 \\ \cdots \\ \cdots \\ \cdots \\ 1\ \Sigma_n\ \Sigma_n^2 \end{bmatrix} \quad \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \end{bmatrix} \quad \epsilon = \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ . \\ . \\ . \\ \epsilon_n \end{bmatrix}$$

and with b_0, b_1, and b_2 being estimates of β_0, β_1, and β_2. ϵ is a vector of error terms representing the amount by which the predicted and true values differ due to random variation. The b's are chosen via linear second-order regression, using the RS/1 "fit multiple" software (BB&N, 1992).

The model is to be developed using PCT results for test glasses (containing non-radioactive isotopes of the fission products, uranium, and thorium), fabricated to have compositions within or surrounding the West Valley process region. The domain of the model will be three times the width of the expected process region for each of the nine oxides used in the model. Values for the expected process region for these oxides are SiO_2:38.73-43.23 weight percent oxide (WPO); Al_2O_3: 5.43-6.57 WPO; ZrO_2:1.12-1.52 WPO; ThO_2: 2.67-4.09 WPO; Na_2O: 7.00-9.00 WPO; K_2O: 4.37-5.63 WPO; Li_2O: 3.25-4.14 WPO; B_2O_3: 10.96-14.82 WPO; Fe_2O_3: 10.22-13.82 WPO.

The index Σ is a weighted sum of key glass elements; more mathematically stated it is a transformation of the independent variables (the key glass elements) in the sense described in Chapter 5 of Draper and Smith (1981). Such a transformation is useful in that the linear combination can correlate better in a regression with the predicted quantity than the group of individual variables. The question is how to determine a good combination. The CUA experience mentioned above gives the form of the combination:

$$\Sigma = Si + a_1Zr + a_2Th + a_3B + a_4\left(\frac{Na + K + Li}{Al}\right),$$

The specifics of how the "a" and "b" coefficients will be determined will be explained in the WQR. The process is expected to involve using the RS/1 software regression capabilities (BB&N, 1992) to fit the model (i.e. estimate the coefficients). The data used to fit the model will be from a database of test glasses within the desired model domain which was discussed above.

West Valley PCT Model Uncertainty Determination

To estimate the amount of uncertainty associated with the regression model, an upper 95% multiple-use confidence limit will be used. It is the upper function of a two-sided confidence band (Miller, 1981) and allows one to say with 95% confidence that for any Σ within the domain of the regression model, the true value of log [λ] is less than the upper limit. In particular, it provides an upper bound of the true value over any interval on the Σ axis, namely the 95/95 tolerance interval for the glass population.

The upper bound associated with any point on the Σ axis is given by $\hat{\log}[\lambda] + \hat{W}$, where the width $\hat{W}$ between the regression equation value and the upper limit is given by

$$\hat{W} = \sqrt{pF_{0.95}(p,n-p)}\; s \sqrt{\begin{bmatrix}1 & \Sigma & \Sigma^2\end{bmatrix}(X^TX)^{-1}\begin{bmatrix}1\\ \Sigma\\ \Sigma^2\end{bmatrix}} \quad \textit{for every} \quad \begin{bmatrix}1\\ \Sigma\\ \Sigma^2\end{bmatrix}$$

in the domain of the regression. $F_{0.95}(p,n-p)$ is the 95th percentile of the F distribution with p numerator and n-p denominator degrees of freedom, and $\Sigma_1,\ldots,\Sigma_n$ are the index values for the n data points used in the development of the regression equation. The derivation of this equation follows Draper and Smith (1981) and Miller (1981). The value of p will depend on how the "a" and "b" coefficients in the model are obtained; details will be provided in the WQR.

To ensure that all waste glass will meet the PCT acceptance criteria, no batch of feed slurry will be released from the CFMT for processing until its composition is acceptable. As discussed in Section 1.1.2, this means that the feed slurry will not be transferred to the MFHT until the high predicted PCT leachate concentration for a glass of the slurry oxide composition is less than the EA glass standard.

$$s^2 = \frac{\textit{residual sum of squares}}{n-p},$$

$$X^TX = \begin{bmatrix} n & \sum_{i=1}^{n}\Sigma_i & \sum_{i=1}^{n}\Sigma_i^2 \\ \sum_{i=1}^{n}\Sigma_i & \sum_{i=1}^{n}\Sigma_i^2 & \sum_{i=1}^{n}\Sigma_i\Sigma_i^2 \\ \sum_{i=1}^{n}\Sigma_i^2 & \sum_{i=1}^{n}\Sigma_i^2\Sigma_i & \sum_{i=1}^{n}(\Sigma_i^2)^2 \end{bmatrix}$$

Statistical Comparison Strategy

The statistical comparison of the production glass predicted PCT response and the EA glass standard is as follows. The $\widehat{\log}[\lambda]$ is predicted as a function of the Σ index, for B, Li, and Na, using the modeling approach described above and finalized in the WQR. Note that the Σ index will be different for each of the three normalized elemental re- leases (B, Li, and Na). This is because each of the leachants (B, Li, Na) behaves differently when subjected to water. The best prediction for each of the three different behaviors is obtained by using a transformation Σ tailor made for the leachant.

As a measure of model uncertainty, an upper 95% multiple-use confidence limit will be formed for each of the three models (referred to in the text below as an "upper curve"). A multiple-use confidence limit was chosen to allow it to be used at any point within the domain of the model, and in particular over the entire 95/95 tolerance interval for the glass population. The general form of the model and upper curve functions are shown in Figure 4. In actuality there are three such graphs, one each for B, Li, and Na.

A bound for the production glass PCT response can be determined by using the upper curve of Figure 4. Given that the PCT response function produces a curve which is concave up, calculation of the upper 95% confidence limit values at each end of the Σ tolerance interval will bound the PCT response of the West Valley glass product. The larger production glass PCT bound from this calculation will be shown to be less than the EA value as the basis for demonstrating compliance with this specification. This method includes the modeling uncertainties via the prediction's upper curve and the glass production uncertainties (sampling, batch-to-batch variation, chemical analysis, etc.) by using the extremes of the Σ tolerance interval. An example graphically showing this methodology is presented in Figure 4.

This comparison procedure will be conducted for each of the three PCT leachate species required, B, Li, and Na. The results of these comparisons will be reported in the Production Records.

Documentation

The WQR will contain details regarding the composition/PCT models, EA glass PCT results, the method of applying them to the production glass data, and identification of the canisters for shard analysis. Production Record contents will be detailed in the WQR; these records will include data on chemical analyses of approximately thirty canistered waste forms, the 95/95 tolerance interval for the corresponding Σ's, the high value for predicted PCT results for B, Li and Na over the glass population, the comparison to the EA value, the predicted PCT results for B, Li and Na for each of the glass samples, and the mean of these predicted PCT results. Finally, verification that the production glass is in compliance with this specification will be included in the Production Records.

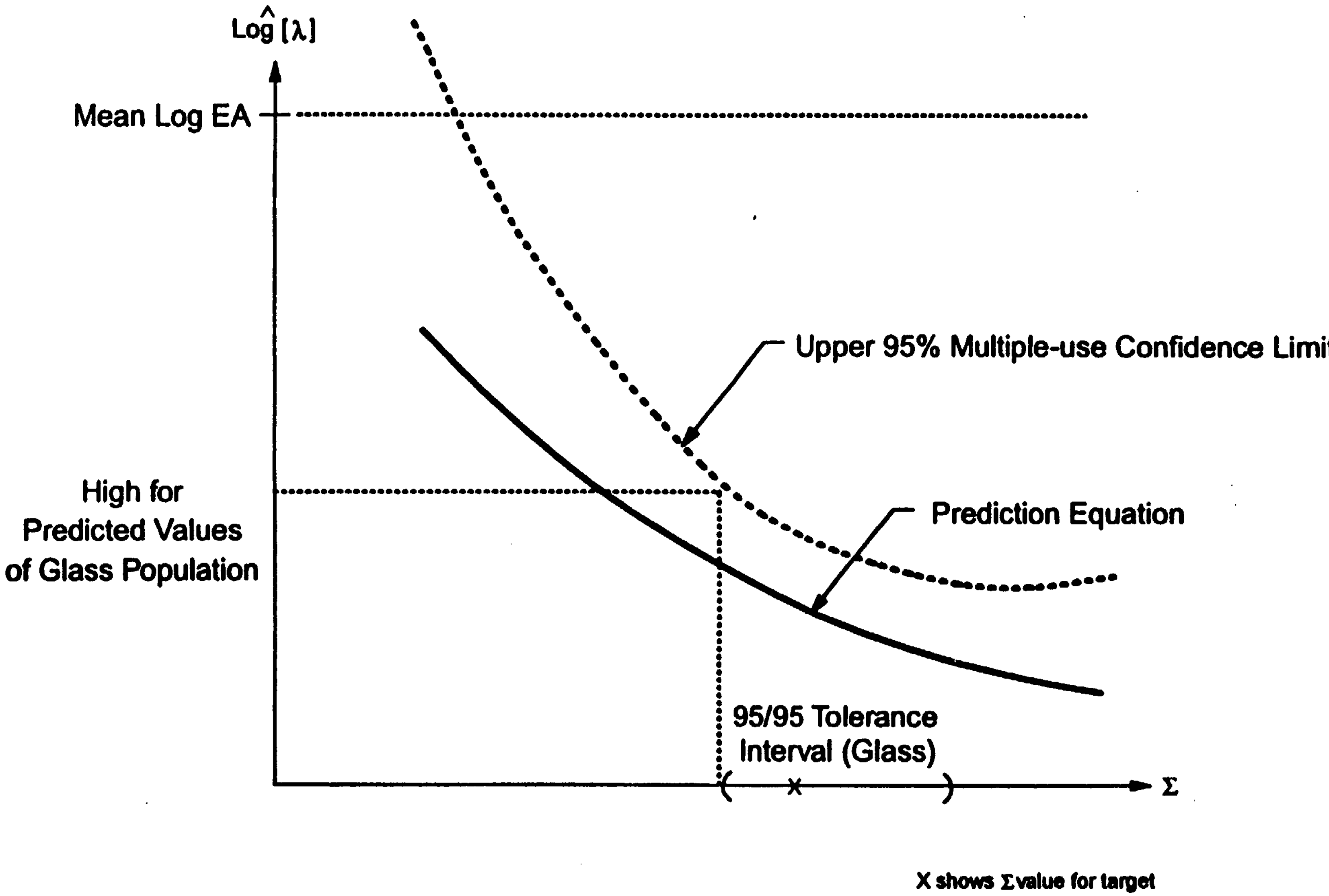

Figure 4. PCT Leachate Concentration Predicted from Composition of Glass
(There will actually be three graphs of this form, one each for B, Li, and Na.)

1.4 Specification for Phase Stability

1.4.1 Phase Stability Information

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

(a) The glass transition temperature; and

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

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

1.4.2 Control of Temperature for Phase Stability

At the time of shipment, the producer shall certify that after the initial cool-down, the waste form temperature has not exceeded 400°C. The producer shall describe the method of compliance in the WCP.

Compliance Strategy

The glass transition temperature will be measured on the target glass composition shown in Table 3. Also, for the target glass composition, the effect of redox and thermal history on the glass transition temperature will be evaluated. The West Valley canister storage facility is being designed to maintain the maximum glass temperatures below 400°C. Thermal analysis calculations will be performed to show that the maximum temperature limit of 400°C during storage and at the time of shipment is not exceeded.

The time-temperature-transformation (TTT) diagram will be developed over the applicable time and temperature range for the target glass composition. Also, the effect of redox, and thermal history on the phase stability of the target glass composition will be determined. These investigations will be reported in the WQR.

Implementation

Glass Transition Temperature

The glass transition temperature is that temperature reached during cooling when a super-cooled liquid becomes a glass. More specifically, it is the temperature at which a marked change in atomic mobility takes place. Typically, the glass transition occurs over a short temperature range. Below this range atomic mobility is too limited to allow secondary phase formation, and above this range the glass becomes more like a liquid because its atomic mobility is increased. Above the glass transition temperature nucleation and growth of second phases are possible up to the liquids 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 at the glass transition temperature is generally detected by thermal expansion measurements using dilatometry and/or by differential scanning calorimetry.

When the dilatometric technique is used, a sharp increase in thermal expansion is noted at the glass transition temperature range as the glass sample is heated. The glass transition temperature is determined by the intersection of the extrapolated lower temperature expansion response and the higher temperature expansion response. In the case of differential scanning calorimetry, an exothermic shift in the baseline is detected at the glass transition temperature range, and the glass transition temperature is defined as the onset of this exothermic shift.

The glass transition temperature (T_g) for the target glass composition will be measured by differential scanning calorimetry and/or dilatometry or both. The effect of redox and thermal history on the glass transition temperature for the target glass composition will be determined by reducing and heat treating glasses in the laboratory. The data will be reported in the WQR.

Time-Temperature-Transformation (TTT) Response

As discussed above, at temperatures above the glass transition temperature, atomic mobility can permit nucleation and growth of secondary phases. Defining this behavior is facilitated through the use of a TTT diagram. The TTT diagram is a graphical representation of the extent of isothermally induced crystallization in glass samples at specific lengths of time.

The WVDP will provide in the WQR the TTT diagram for the target glass composition (containing Th and U) and show that this is an adequate representation of TTT behavior for the expected range of variation around the target composition. Phases resulting from the heat treatments will be identified by type and volume percent abundance using standard analytical techniques (e.g., optical microscopy image analysis, x-ray diffraction, scanning transmission electron microscopy).

Additionally, during FACTS at WVDP, samples from the melter pour stream and from the filled canisters have been extracted and will be compared in the WQR with glasses heat treated in the laboratory. The samples from the melter pour stream will provide an indication of the effect of pre-existing crystals.

The temperatures used to develop the TTT curve will be between the glass transition temperature and the liquids temperature. Heat treatment times will be from a minimum of 0.5 hours up to the longest time that is necessary for the canistered glass to reach below the glass transition temperature.

Canistered Waste Form Storage and Shipment

The maximum glass temperature, after initial cooldown and during storage and at the time of shipment to the repository, will be shown to be below 400°C. This will be based upon considerations of the West Valley canister geometry (Figure 5, Section 2.2), a radionuclide inventory loading representing an upper activity bounded canister (Section 1.2), and assumptions of credible ambient air temperatures. The nuclide heat generation rate will be calculated using the ORIGEN2 computer program. The heat source will then be input into a thermal analysis computer program such as HEATING5 (Turner, 1977). 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 inputs. Even though the temperature of the canistered waste form will not be measured directly, thermal analysis calculations,

based on measured (monitored) storage facility temperature data, will show that the canistered waste form never exceeded 400°C during storage. The heat transfer rates through a canister and from the canister surface are both sufficiently high in comparison to the heat generated within the canister that only a small temperature difference exists between the canister and the surrounding air. It will be shown that even without forced ventilation, the canister will never exceed 400°C. The Storage and Shipping Records will include certification that the canistered waste form never exceeded 400°C during storage.

The West Valley storage facility, which is physically located in the existing plant Chemical Process Cell (CPC), is being designed to maintain the maximum glass temperature below 400°C. The ventilation flow in the CPC is through the Equipment Decontamination Room (EDR) to the CPC and is ducted from the CPC to the main plant contamination control ventilation system. The flow through the cell is 170,000 to 230,000 liters/min. (6,000-8,000 ft^3/min) of unconditioned outside air. Even if the CPC contains the full inventory of WVDP radioactive canisters, the normal ventilation airflow will be sufficient to keep the CPC air temperature below 50°C (122°F) as long as circulation is maintained in the cell. The ventilation system is backed up by spares and operates on the backup power system. Additional cooling may be used in the CPC to condition the air and lower temperatures even further to protect electronic equipment such as crane controls and video cameras.

Documentation

The WQR will discuss experimental techniques and provide the transition temperature and TTT diagram for the WVDP glass waste form. The WQR will provide calculations designed to predict the maximum temperature of the canistered waste form during storage. The Storage and Shipping Records for each canistered waste form will also include a certification that after the initial cool-down, the maximum glass temperature never exceeded 400°C based on monitored cell temperatures during storage.

1.5 Hazardous Waste Specification

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

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

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

Compliance Strategy

The WVDP glass waste form is not a "listed" hazardous waste. To assess whether the vitrified glass product is a "characteristic" waste, prototypical WVDP glass compositions will be prepared and evaluated using the TCLP leach test.

Implementation

The WVDP glass waste form is subject to regulation under the Resource Conservation and Recovery Act or RCRA, administered by the Environmental Protection Agency but delegated to the New York State Department of Environmental Conservation. The high level nuclear waste at WVDP is not a listed RCRA hazardous waste. As will be discussed in the WQR, the nuclear waste reprocessing streams and other process streams that constitute the high level waste stored in the tanks at West Valley are not "listed" in the tables of wastes as defined in 40CFR261.31 through 40CFR261.33. Accordingly, by regulatory definition, the WVDP glass waste form can not be classified as a "listed" hazardous waste.

Although not a listed waste, the WVDP waste form may possess certain attribute(s) that, by regulation, classifies it as a "characteristic" hazardous waste. Under RCRA, a characteristic waste must have one or more of the following attributes: corrosivity, ignitability, reactivity and toxicity. Since the first three attributes do not apply to the WVDP solid waste form, only the toxicity characteristic, which relates to the leachability of certain hazardous contaminants* from the glass into an aqueous environment, must be demonstrated to be acceptably low to avoid classifying WVDP glass as a "characteristic" hazardous solid waste.

WVDP intends to comply with this specification by using the EPA designated Toxicity Characteristic Leaching Procedure (TCLP) test to demonstrate that leaching of the principal hazardous components from the waste form such as Cr, Ba, Cd, etc., are well below regulatory limits. Nonradioactive surrogate glass samples having the target composition as well as glasses with one other composition bounding the WVDP glass process region and shown by PCT to exhibit the highest releases of Li, Na, and B will be formulated to contain the hazardous elements expected to be present during radioactive operations. These glasses will be melted, chemically analyzed and sent to a State of New York certified laboratory for TCLP testing. In addition, glass compositions similar to the above glasses but containing up to three times the quantity of hazardous metals will also be prepared, analyzed and TCLP tested. This experiment will serve to demonstrate that the WVDP waste form is in environmental compliance with RCRA requirements even when it contains a large excess (3X) of hazardous contaminants. The results of these tests will be reported in the WQR.

It is extremely unlikely that the WVDP glasses will fail the TCLP test since the principal basis for accepting borosilicate glass waste forms by DOE as the primary method for immobilizing HLW was its high resistance to leaching. However in the unlikely event that unacceptable leaching occurs, the WVDP waste form will be reclassified as mixed (hazardous plus radioactive) waste and a Hazardous Waste Manifest will be provided in the Production Records.

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* As, Ag, Ba, Cd, Cr, Pb, Hg, and Se are the designated inorganic contaminants for the toxicity characteristic in 40 CFR 261.24.

Documentation

The WQR will document that the WVDP waste tanks do not contain listed hazardous waste and that the WVDP vitrified waste form is therefore not a hazardous listed waste. The WQR will also contain the results from the chemical analyses and TCLP tests on the WVDP glasses and an evaluation as to whether the waste form is a characteristic hazardous waste. If the glass waste form is found to be hazardous, the Production Records will contain a Hazardous Waste Manifest.

2.0 CANISTER SPECIFICATIONS

2.1 Material Specification

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

Compliance Strategy

Confirmation that the materials used in the as-fabricated canister, including any secondary canisters, comply with this specification will be provided by material test reports, analytical testing, and detailed inspection of the component parts. The fabricator will provide procurement and fabrication reports documenting: a) that certified materials were used; and b) the heats, traceable to each canister, (including the chemical analysis of the heats) from which the canister parts were fabricated. Canisters, including any secondary canisters, will be inspected and tested and material conformance verified by a quality assurance representative at the fabricating vendor.

Implementation

West Valley will fabricate its canisters, including any secondary canisters, from austenitic stainless steel 304L; the composition of this alloy is given in Table 11. At present, it is planned that the canister heads and barrel will be made of ASTM A240 plate type 304L stainless steel and the flange will be 304L stainless steel pipe per ASTM A312, plate per ASTM A240, or forging per ASTM 182. The composition of ASME SFA5.9 ER308L austenitic stainless steel, the weld filler metal, which may be used to assemble the canister from its component parts is given in Table 12. The 308L alloy will also be used for the weld beaded canister identification labels.

The WVDP canister fabrication or equipment specification document (to be provided as a part of the WQR Section 2.2) will require that the fabricator use certified materials and provide certified material test reports on the heats from which the canister parts were made. In addition, WVDP will also require that the results of a second chemical analysis, performed by an independent laboratory, be provided for each metal heat used.

TABLE 11

CHEMICAL COMPOSITION REQUIREMENTS FOR ASTM A240
TYPE 304L STAINLESS STEEL (S30403)

ELEMENT	PERCENT*
C	0.03
Mn	2.00
P	0.045
S	0.03
Si	0.75
Cr	18.00-20.00
Ni	8.00-12.00
N	0.10
Fe	Balance

* Maximum values unless range is indicated.

TABLE 12

CHEMICAL COMPOSITION REQUIREMENT
OF TYPE 308L STAINLESS STEEL WELD
METAL, ER308L (W30843)

ELEMENT	PERCENT*
C	0.03
Cr	19.50-22.00
Ni	9.00-11.00
Mo	0.75
Mn	1.0-2.5
Si	0.30-0.65
P	0.03
S	0.03
Cu	0.75
Fe	Balance

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

Canister inspections, as specified in the fabrication specification, will be performed by the fabricator and witnessed by a WVDP representative. A detailed document review will be performed and material conformance verified by a WVDP quality assurance representative prior to release for shipment to WVDP . Canisters with nonconforming materials will not be accepted for WVDP use.

Documentation

The WQR will specify the metal alloys (manufactured to ASTM (or ASME) specifications) to be used in canister fabrication and the controls and inspections required to ensure that the materials are properly certified and identified. The Production Records will include verification that the materials test reports for every canister and its component parts are satisfactory.

2.2 Fabrication and Closure Specification

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

Compliance Strategy

It is currently planned that the WVDP stainless-steel canister will be fabricated from rolled plate for the cylindrical body, the dished head, and the reverse dished bottom; pipe or forgings may be used for the flange. Canister integrity will be ensured by specifications of the components, by specification of the method of fabrication, and by a rigorous program of inspection and verification. Final, leaktight (as defined in this specification) weld closure of the canisters will be performed as soon as practical after filling and will effectively isolate the waste glass from the environment during subsequent handling and storage. The resistance of the final lid closure to leakage will be ensured at WVDP by close control of the welding process and by weld inspection.

Implementation

The current West Valley canister design is shown in Figure 5. At this time, WVDP plans to have its canister fabricated by cold rolling stainless steel plate with a nominal thickness of 0.135 inches (0.34 cm) to form the canister wall. The canister bottom will be a flanged and reverse dished head; the top will be a flanged and dished head. The top and bottom thicknesses are shown to be 0.188 inches (0.48 cm). The lifting flange may be fabricated from pipe as shown in Figure 5.

The WVDP canister fabrication or equipment specification (to be included as an attachment to WQR Section 2.2), which will be provided to the fabricator, details the canister materials, the procedural protocols, and the acceptance requirements. A WVDP quality assurance field representative will verify that the canister fabrication specifications have been followed by inspections at the fabricator's shop. Fabrication welding will utilize the gas tungsten arc welding (GTAW) process. All fabrication welds will be inspected by dye penetrant according to Section V of the ASME Boiler and Pressure Vessel Code* and meet the criteria of Section IX.

* Applicable sections of the ASME Boiler and Pressure Vessel Code are referenced for welding and nondestructive evaluation, but the canister is not classified as a code vessel.

Certifications that the welds were made and inspected as specified will be required from the fabricator. Canister documentation inspection will verify that these certifications are included. After weld fabrication, the canisters will be labeled (see Section 2.3), weighed and helium leak tested to assure leak tightness less than 1 x 10^{-4} atm-cc/sec helium.

The WVDP will perform inspection data reviews as part of the fabrication effort to ensure that the canisters comply with design requirements. WVDP quality representatives will verify that the inspections required by the canister equipment specification were completed and acceptable. The specific inspections (dimensional verification, wall thickness, unique label, etc.) will be listed in the WQR. Verification that each assembled HLW production canister and its components were fabricated according to approved drawings and procedures and meet procurement specifications will be documented by WVNS Certificates of Compliance in the Production Records.

Canisters received by the WVDP will be subjected to inspections for damage incurred in shipping. Any canisters that are found to be damaged will be treated as nonconforming items and returned to the vendor.

Final weld closure of the WVDP canisters will be performed in the Vitrification Facility at the earliest practical time after filling. Canisters will be transferred from the turntable to a welding station where shard samples will be removed, weld surface preparation performed, and welding of the lid onto the canister completed. Under normal process conditions, it is likely that weld closure will be performed within about two days after the canister is removed from the turntable. In the time period after glass filling, the WVDP turntable design will protect against the entry of prohibited substances into the canister. However, in the event that the filled but open canister must be removed from the turntable, but cannot be directly transferred to the weld station for lid closure, temporary canister lid covers will be used to protect the canister contents. The austenitic stainless steel temporary cover is not intended to provide a leak tight seal but is designed to completely cover the canister opening; the cover will be emplaced on the canister by a special adapter mounted on an impact wrench attached to the process crane. Care will also be taken to insure that the dew point of water vapor contained in the gas inside the weld-sealed waste filled canister will be below the anticipated canister storage temperature. This could be accomplished by purging the filled canister with dry air or dry inert cover gas just prior to welding the lid.

The current reference closure method for sealing the lid onto the WVDP canister will be by pulsed gas tungsten arc welding (GTAW). The lid and canister top design are shown in Figures 5 and 6. The pulsed GTAW system will employ a fixture that attaches to the canister top enabling the weld head to rotate around it. The weld station equipment will also include a rework tool in case weld repairs or a secondary lid is needed.

A weld development program is being defined to determine the parameters necessary to achieve the specified canister leak tightness. Weld parameters and process variables to be investigated for their effect on weld quality may include surface preparation, weld area cleanliness, fit-up tolerances, pulse current, background current, pulse times, travel speed, and cover gas flow.

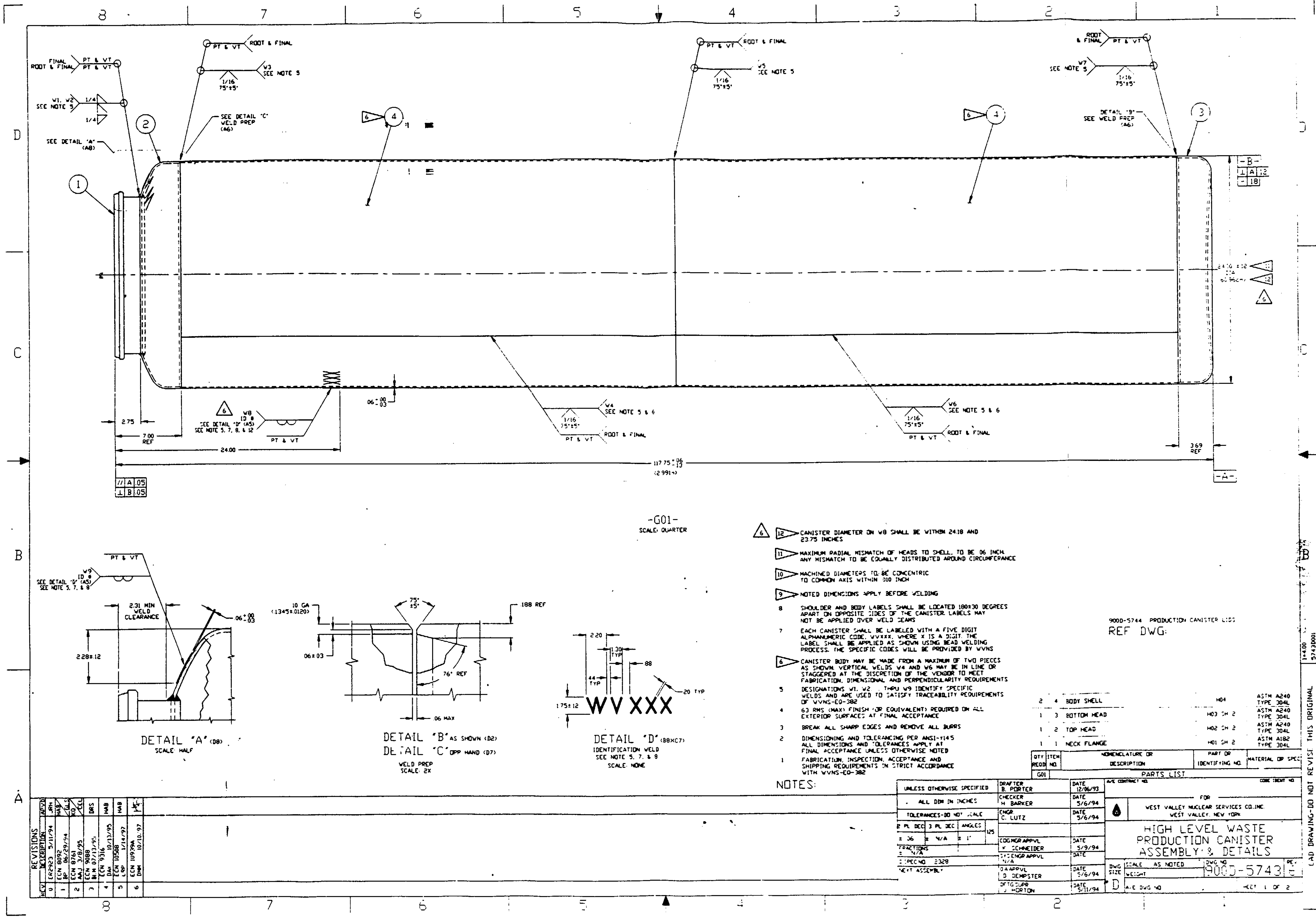

-G01-
SCALE: QUARTER
DETAIL 'A' (D8)
SCALE: HALF
DETAIL 'B' AS SHOWN (D2)
DETAIL 'C' OPP HAND (D7)
WELD PREP
SCALE: 2X
DETAIL 'D' (B8XC7)
IDENTIFICATION WELD
SEE NOTE 5, 7, & 8
SCALE: NONE
WV XXX
12 CANISTER DIAMETER ON W8 SHALL BE WITHIN 24.18 AND 23.75 INCHES
11 MAXIMUM RADIAL MISMATCH OF HEADS TO SHELL TO BE .06 INCH. ANY MISMATCH TO BE EQUALLY DISTRIBUTED AROUND CIRCUMFERANCE
10 MACHINED DIAMETERS TO BE CONCENTRIC TO COMMON AXIS WITHIN .010 INCH
9 NOTED DIMENSIONS APPLY BEFORE WELDING
8 SHOULDER AND BODY LABELS SHALL BE LOCATED 180±30 DEGREES APART ON OPPOSITE SIDES OF THE CANISTER. LABELS MAY NOT BE APPLIED OVER WELD SEAMS
7 EACH CANISTER SHALL BE LABELED WITH A FIVE DIGIT ALPHANUMERIC CODE, WVXXX, WHERE X IS A DIGIT. THE LABEL SHALL BE APPLIED AS SHOWN USING BEAD WELDING PROCESS. THE SPECIFIC CODES WILL BE PROVIDED BY WVNS
6 CANISTER BODY MAY BE MADE FROM A MAXIMUM OF TWO PIECES AS SHOWN. VERTICAL WELDS V4 AND V6 MAY BE IN LINE OR STAGGERED AT THE DISCRETION OF THE VENDOR TO MEET FABRICATION, DIMENSIONAL AND PERPENDICULARITY REQUIREMENTS
5 DESIGNATIONS W1, W2 THRU W9 IDENTIFY SPECIFIC WELDS AND ARE USED TO SATISFY TRACEABILITY REQUIREMENTS OF WVNS-EO-382
4 63 RMS (MAX) FINISH (OR EQUIVALENT) REQUIRED ON ALL EXTERIOR SURFACES AT FINAL ACCEPTANCE
3 BREAK ALL SHARP EDGES AND REMOVE ALL BURRS
2 DIMENSIONING AND TOLERANCING PER ANSI-Y14.5. ALL DIMENSIONS AND TOLERANCES APPLY AT FINAL ACCEPTANCE UNLESS OTHERWISE NOTED
1 FABRICATION, INSPECTION, ACCEPTANCE AND SHIPPING REQUIREMENTS IN STRICT ACCORDANCE WITH WVNS-EO-382
NOTES:
9000-5744 PRODUCTION CANISTER LIDS
REF DWG.
2 4 BODY SHELL H04 ASTM A240 TYPE 304L
1 3 BOTTOM HEAD H03 SH 2 ASTM A240 TYPE 304L
1 2 TOP HEAD H02 SH 2 ASTM A240 TYPE 304L
1 1 NECK FLANGE H01 SH 2 ASTM A182 TYPE 304L
PARTS LIST
REVISIONS
0 ER2923 5/11/94 JRH
1 ECN 8092 BP 06/29/94 HAB
2 ECN 8761 AAJ 3/8/95 KO
3 ECN 9088 BLM 07/13/95 DRS
4 ECN 9316 DAK 10/13/95 HAB
5 ECN 10508 LRP 1/14/97 HAB
6 ECN 10939A DHM 10/10/97
UNLESS OTHERWISE SPECIFIED
ALL DIM IN INCHES
DRAFTER B. PORTER 12/06/93
CHECKER H. BARKER 5/6/94
ENGR C. LUTZ 5/6/94
COG MGR APPVL K. SCHNEIDER 5/9/94
QA APPVL D. DEMPSTER 5/6/94
WEST VALLEY NUCLEAR SERVICES CO. INC.
WEST VALLEY, NEW YORK
HIGH LEVEL WASTE
PRODUCTION CANISTER
ASSEMBLY & DETAILS
SCALE AS NOTED
DWG SIZE D
9000-5743
SHEET 1 OF 2
CAD DRAWING-DO NOT REVISE THIS ORIGINAL

Figure 5

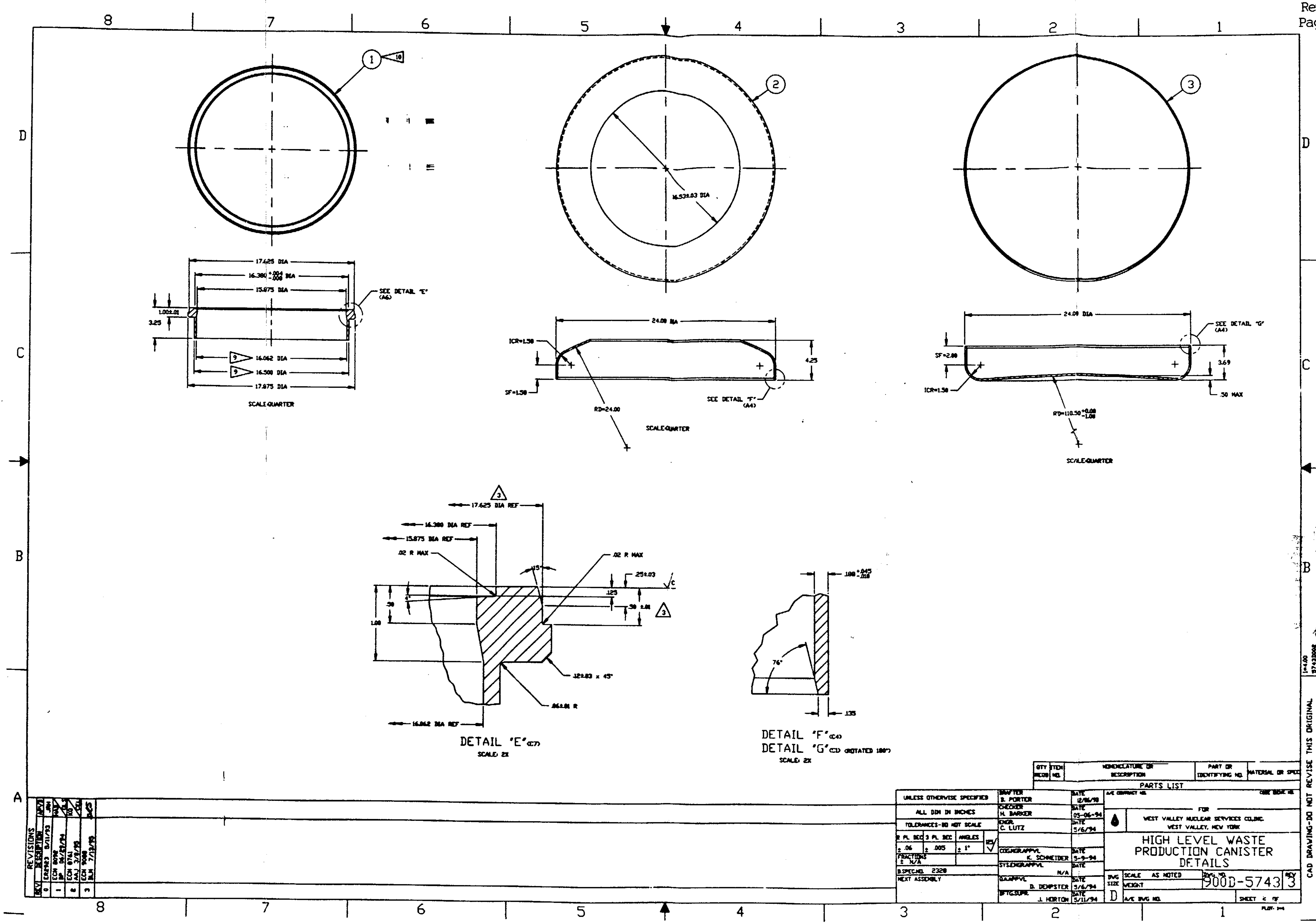
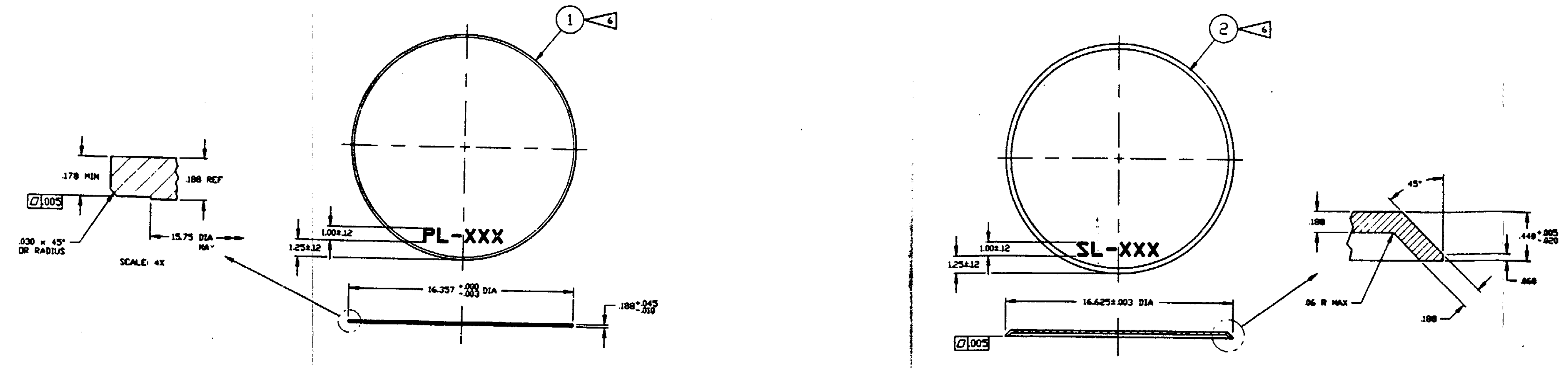


Figure 5 (cont'd)



7. PRIMARY LIDS SHALL BE SHIPPED IN LID PACKAGES AS SHOWN ON 900D-6964.
6. EACH LID SHALL BE LABELED WITH A FIVE DIGIT CODE, PL-XXX OR SL-XXX, WHERE X IS A DIGET. THE LABEL SHALL BE TEMPLATE AND BEAD BLAST (OR EQUIVALENT) APPLIED. THE SPECIFIC CODE WILL BE PROVIDED BY WVNS. LOCATE AS SHOWN ON UPPER SURFACE
5. HOT ROLLED, ANNEALED, AND PICKLED FINISH REQUIRED PRIOR TO PROCESSING
4. 63 RMS (MAX) FINISH (OR EQUIVALENT) REQUIRED ON ALL UPPER SURFACES EXCEPT LABEL
3. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS
2. ALL DIMENSIONS AND TOLERANCES APPLY AT FINAL ACCEPTANCE
1. FABRICATION, INSPECTION, ACCEPTANCE AND SHIPPING REQUIREMENTS IN STRICT ACCORDANCE WITH WVNS-EQ-382

NOTES:

900D-5743 SH 1 & 2 - PRODUCTION CANISTERS

REF DWG:

QTY REQD	ITEM NO.	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	MATERIAL OR SPEC
	2	SECONDARY LID	H02	ASTM A240 TYPE 304L
	1	PRIMARY LID	H01	ASTM A240 TYPE 304L

PARTS LIST

REV	DESCRIPTION	DRS	APVD
0	ER2823 5/11/94		
1	ECN 8090 BP 06/29/94		
2	ECN 8761 MAJ 3/8/95		
3	ECN 9088 BLM 7/13/94		
4	ECN 9378 NJL 10/27/95		
5	ECN 9831 JLH 4/22/96		

REVISIONS

UNLESS OTHERWISE SPECIFIED
ALL DIM IN INCHES
TOLERANCES-DO NOT SCALE
2 PL DEC ±.03 | 3 PL DEC ±.010 | ANGLES ±1° | 125
FRACTIONS ± N/A
D.SPEC.NO. 2328
NEXT ASSEMBLY

DRAFTER B. PORTER DATE 12/16/93
CHECKER H. BARKER DATE 05-06-94
ENGR. C. LUTZ DATE 5/6/94
COG.ENGR.APPVL K. SCHNEIDER DATE 5-9-94
SYS.ENGR.APPVL N/A DATE
QA APPVL D. DEMPSTER DATE 5/6/94
DFTG.SUPR. J. HORTON DATE 5/11/94

A/E CONTRACT NO. CODE IDENT. NO.
FOR
WEST VALLEY NUCLEAR SERVICES CO. INC.
WEST VALLEY, NEW YORK

HIGH LEVEL WASTE
PRODUCTION CANISTER LIDS
DETAILS

DWG SIZE D | SCALE AS NOTED | WEIGHT | DWG NO. 900D-5744 | REV 5
SHEET 1 OF 1

CAD DRAWING-DO NOT REVISE THIS ORIGINAL

Figure 6

Weld qualification will be evaluated via metallographic examinations, burst tests and/or tensile and bend weld zone coupon tests and helium leak tests. Helium leak tightness measurements will be performed using the Helium Mass Spectrometer Leak Testing Method in accordance with ASME - Section V, Article 10, 1989 edition including 1990 addenda. Tests will be performed on full-sized canisters and on dummy canister tops that duplicate the upper 18 inches of the production canister. Those parameters that produce an integral leak tight closure will form the basis for the welding procedure that will be used for the routine closure of production canisters. In-cell visual inspection of the closure welds will augment weld parameter control as a means of assessing weld quality. The ability to visually resolve pores, cracks, spatter marks, and incomplete fusion under viewing conditions simulating those expected in-cell will be evaluated and the relevance of visual inspection results to weld quality will be discussed in the WQR.

Documentation

The WQR will include the WVDP canister fabrication or equipment specification. The results of the closure weld development and qualification program will be reported and referenced in the WQR. The Production Record for each canistered waste form will certify that canister components and the entire canister were fabricated according to approved drawings and procedures and meet procurement specifications. WVNS Certificates of Compliance verifying that canisters were fabricated according to specification will be included in the Production Records. The Production Record will also verify the integrity of the final closure weld made at WVDP by reporting the critical welding process parameter values from the closure operation and the visual inspection results.

2.3 Identification and Labeling Specification

2.3.1 Identification

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

2.3.2 Labeling

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

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

Compliance Strategy

The code planned for identifying the canistered waste forms is a five character alphanumeric code consisting of two letters and three numbers. The label lettering will conform to the specification. The label itself will be made of an austenitic stainless steel to assure compatibility with the canister. The reference labeling technique will be bead-welding (SS 308L) of the alphanumeric characters directly onto the canister surface (SS 304L). This labeling technique will be shown to be suitable by fabricating full-sized weld-bead labeled canisters, handling and decontaminating the labeled canister in a manner similar to that used in the WVDP process, and then establishing that the labels are still readily legible and not subject to preferential obliteration.

Implementation

Each West Valley canister will have a unique identification code of the form WVXXX where X is a digit. This identification code will appear in the Production Records and the Storage and Shipping Records that describe the canistered waste. The table of contents for the WVDP Production Records is provided in the EM-WAPS. The required Production Record contents, reviews, and issuance instructions will be placed in WVDP procedures.

The identification code will be located on the canister in two places. One on the top shoulder of the canister so that the code can be seen from the top; and the other on the side of the canister about 60 cm from the top as shown in Figure 5. The characters for these labels will be at least 3.25 cm (92 points) and as large as 5.1 cm (144 points) tall and will be modified block; an example of an ideal modified block label and the size and spacing relationships of the characters is shown in Figure 5. Characters will have a profile height not exceeding approximately 0.06 inch (0.15 cm) and the maximum diameter of the canister, without the label, will be 24.12 inch (61.26 cm). Therefore, the maximum diameter of the WVDP canister including the weld bead character will not exceed 24.18 inches (61.42 cm), a value safely below the largest permissible canister diameter of 24.61 inch (62.5 cm) specified in WAPS 2.4.2.

The label characters will be inscribed on the canisters as weld beads using a 308L austenitic stainless-steel welding rod. Since the label will be a weld bead, it will be compatible with the canister and the service life of the label is expected to match that of the canister fabrication welds.

The unique identification code to be assigned to a canister will be provided to the fabricator by the WVDP. Canister inspection will verify that both labels on a canister are the same and that each canister's identification number is unique. WVDP quality representatives will review the canister identification inspection results and place a certificate of compliance in the Production Records. Additional inspections will require that the weld character height profile is correct and that any defects which could trap contamination be removed before the canisters will be accepted at the WVDP.

Before transfer to temporary storage, the labels on the canistered waste form will be visually inspected via a television camera or through a shield window to ensure that the labels are intact (undamaged) and legible. This procedure will also be repeated at shipout before placement of the canisters into the transportation casks. The results of this inspection will be included in the Storage and Shipping Records.

During nonradioactive FACTS testing at WVDP, full scale reference canisters were filled with glass and treated to simulated "rough" handling conditions. The effect of glass pouring and subsequent handling and decontamination has been evaluated and, as will be discussed in the WQR, found not to affect the legibility and durability of the label. A positive assessment has also been made of the ability of the label to remain attached and legible through the normal conditions of transport and handling until the canistered waste form is placed in the repository container.

The WVDP canistered waste form storage facility is being designed to minimize potential canister and label corrosion. In this facility, normal ventilation airflow will maintain the temperature of the canister surfaces sufficiently low to minimize corrosion kinetics but high enough to prevent water condensation on the canister exterior. It is anticipated that the environment for radioactive canister storage at West Valley will be about 50 percent relative humidity air at temperatures less than 50°C. This environment, in the absence of aqueous corrodents (halides), is benign to 304L stainless steel and little impact on label service life would be expected.

Since decontamination experiments also indicate that the oxidation rate of attack on the weld bead label is similar to that of the 0.188 inch (0.48 cm) thick 304L stainless steel base metal (Westerman, 1990), it is anticipated that label lifetime, from the standpoint of general corrosion resistance should conservatively be 1000 years under WVDP storage conditions (Rankin, 1980). Experimental measurements also indicate little evidence for localized weld bead corrosion even following exposure to the extremely oxidizing Ce^{+4}/HNO_3 decontamination environment. Microhardness scans in the base metal and in the canister weld zones reveal no brittle phases. The microhardness measurements also indicate nearly identical hardness values within the weld bead character and in the base metal. This suggests that the label is not any more susceptible to damage and deformation (which could affect legibility) than the canister base metal itself. Despite all precautions that will be taken during canister handling and storage operations at West Valley, a small probability exists that both labels in the canister could become obliterated. To ensure that canister identity is never compromised even in this unlikely event, WVDP will maintain a map that will identify the location of every canister in the CPC storage facility.

Documentation

The WQR will report on the identification code, the labeling materials and technique and the durability and legibility of the label under processing and storage conditions. The Production Records and the Storage and Shipping Records will identify each canister by its unique code. The Storage and Shipping Records will report on canister label legibility before shipout.

2.4 Specification for Canister Length and Diameter

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

2.4.1 Length Specification

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

2.4.2 Diameter Specification

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

Compliance Strategy

The specified maximum and minimum length and diameter of the unfilled WVDP canister has been designed to be safely within those required by this specification. As-built canister lengths and diameters will be provided for all production canisters.

Implementation

For all production canisters, WVDP will specify in the canister fabrication or equipment specification and in its contract drawing(s) the maximum and minimum pre-pour lengths and diameters to assure that they never violate the range of length and diameter values mandated by this specification. As shown in the proposed WVDP canister drawing in Figure 5, the canister length without the lid can not exceed 117.81 inches (2.992 meters). For a scenario where the 0.188 inches thick closure lid is welded onto the canister but does not properly recess into the top flange of the canister, the total canister length with lid will be at most 118.0 inch or 2.997 meters, below the maximum specified length of 3.005 meters. A worst case situation might arise if the 0.440 inch thick secondary lid (see Figure 6) must be welded to the canister top. In this case, the total length would be 118.25 inches or 3.004 meters which is still below the maximum allowable length in this specification.

Similarly, Figure 5 mandates that the maximum diameter of the canister (24.12 inches or 61.26 cm) plus that due to the weld bead character height (0.06 inches or 0.15 cm) must not exceed 24.18 inches or 61.42 centimeters, a value safely below the largest permissible canister diameter of 62.5 centimeters.

The minimum diameter, as specified in Figure 5, is the diameter of the canister at the label elevation, not including the weld bead character height. This is given as 23.69 inch (23.75 - .06 inch) or 60.18 cm (60.33 - .15 cm), values well within the specification requirements.

The canister length, the average closure lid thickness, and the diameter of each as-built, unfilled canister will be measured at the canister (or parts) fabricator, and will be reported in the Production Records.

Documentation

The Production Records will provide the as-built measured lengths and diameters for all canisters.

3.0 CANISTERED WASTE FORM SPECIFICATIONS

3.1 Free-Liquid Specification

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

Compliance Strategy

The vitrification process will evaporate free liquid from the waste slurry feed in the melter. The canisters will be inspected prior to entry into the WVDP Vitrification Facility to ensure they contain no drainable liquid. Administrative controls and timely permanent weld closure of the canister lid will ensure that free liquid cannot enter, or condense inside, the filled waste canister.

Implementation

Since the vitrification process will take place at about 1150°C and <1 atm with a nominal melter residence time of 65 to 70 hours, all liquid in the waste feed will be evaporated from the glass. The empty canisters will be inspected prior to entry into the Vitrification Facility to ensure that they do not contain drainable liquids. Any trace of free liquid residing in the empty canister is expected to evaporate as the canister is filled with the hot glass (temperatures >1000°C). The transition temperature (Section 1.4) defines the temperature limit below which the glass is phase stable; therefore, no free liquid would be expected to be generated within the glass up to that limit. Experiments to verify this assessment will be reported in the WQR. In these tests, simulated waste glass will be annealed for extended times at temperatures approximating the glass transition temperature and will be monitored for free liquid formation and release of condensable volatiles.

The ingress of free liquids and other prohibited materials into the canisters will be prevented by a series of procedures and specifications (and associated documentation) known as administrative controls. These controls include procurement and handling specifications requiring the canisters to be cleaned by the fabricator and to be protected from contamination during shipment to West Valley. The canisters will be inspected and cleaned, if warranted, prior to transfer to the WVDP Vitrification Cell. In cell, the melter turntable covers the canister openings to prevent possible contamination by prohibited substances. The crane and grapple are designed to contain a minimum amount of lubricants that could drip into the canister. The grapple is also designed to cover the canister mouth with a stainless steel plate during handling. Only inert gas or nitrogen will be used in the welding process and no "prohibited" (see Section 3.2) gases will be intentionally introduced into the Vitrification Cell. Furthermore, temporary covers to protect the mouth of the canister as well as its contents will be used in the Vitrification Cell.

The aqueous decontamination solution is a potential source of free liquids in the canister. However, since canister lid weld closure precedes the WVDP decontamination process (see Section 3.6), it is not possible for the decontamination fluids to enter the canister. Furthermore, the use of dried gases to purge the filled canister before final lid weld closure can be used if necessary to prevent water vapor from condensing inside the canister, i.e., the dew point of any entrapped water vapor will be below the canister storage and anticipated repository temperatures.

Documentation

The WQR will report on the absence of free liquids in the waste glass and on the controls used to prevent free liquids from entering the canistered waste form.

3.2 Gas Specification

The producer shall ensure that the canistered waste form does not contain detectable amounts of free gas other than air, the residuals of air, inert cover, and radiogenic gases. The internal gas pressure immediately after closure shall not exceed 150 kPa (22 psia) at 25°C. The producer shall describe the method of compliance in the WCP and provide documentation of the ability to comply with this specification, and of the detection limits, in the WQR. The producer shall also document in the WQR the quantities and compositions of any gases that might accumulate inside the canister from radiogenic decay in the event that the canistered waste form temperature exceeds 400°C. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C.

Compliance Strategy

Glass pouring and permanent closure of the canister will be in an air atmosphere. Administrative controls, such as visual inspection of the area to ensure that gases other than air and cover gas (helium or argon) are not stored in the cell where the canister closure is performed, will be in place to prevent any undesirable gases entering the canister during closure. The technical literature has been reviewed, and it shows that an insignificant amount of gas would be generated during storage below the glass transition temperature. An estimate of the type and amounts of gases and water vapor, if any, will be based on the results of an experiment where a WVNS canister filled with nonradioactive glass during a FACTS vitrification test will be heated to the glass transition temperature. Any gases evolved will then be analyzed.

The amount of radiogenic gases that could be generated in a canister will be calculated, based on the estimate of radionuclide content of the canister.

Implementation

The waste glass will be poured into the canister in an air environment. Final closure is planned to be at one atmosphere in air and/or inert cover/dry purge gases. Therefore, any void spaces will contain air and/or inert gases.

Data collected during the filled canister heating experiment described above in the Compliance Strategy (and other supporting research published in the literature) will be compiled to provide estimates of the quantities and compositions of gases that could vaporize from the glass near the glass transition temperature. Since the WVDP glass will be stored well below the glass transition temperature (see Section 1.4), this information will provide an upper bound on the amount of anticipated volatility.

The literature review indicates that no significant amount of gas should accumulate inside the canister after closure as a result of the canister being heated up to 500°C (Mendel, 1982; Mendel et al, 1983). This is because the waste glass manufacturing temperatures are many hundreds of degrees above the specified 500°C temperature. Thus, any volatiles that could potentially pressurize the canisters during storage will have evolved during the melting process (Mendel 1978).

Numerous studies to investigate the volatility of glass components when exposed to high temperatures [primarily fires during production or transport (Rusin 1980)] have been conducted at the Pacific Northwest Laboratory (PNL). These studies used an apparatus in which air (either dry or moist) flowed past a heated sample and then past a water cooled "cold finger" where condensables were collected for chemical analysis. The heated sample was 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 et al. 1981, Ross et al. 1978, Wald et al. 1980). Cs was found to be the most volatile. Other studies have also confirmed these behaviors (Hastie 1983, Terai and Kosaka 1976).

Although Cs and other elements are released from the glass, the vapor pressures of the compounds that these elements will form [oxides, hydroxides, or alkali borates (Terai and Kosaka 1976) are extremely low at the 500°C 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° to 750°C, and volatility will not be significant. At the specified temperature of 500°C, the vapor pressures of the compounds that will incorporate the volatilized elements will be even lower.

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

Documentation

The WQR will report on the absence of prohibited free gases in the canistered waste form below the 500°C temperature limit and on the controls designed to prevent the ingress of these gases. Documentation of the amount and composition of gases due to radioactive decay will also be provided in the WQR.

3.3 Specification for Explosiveness, Pyrophoricity, and Combustibility

The producer shall ensure that the canistered waste form does not contain detectable amounts of explosive, pyrophoric, or combustible materials. The producer shall describe the method of compliance in the WCP and provide documentation of the detection limits, and the ability to comply with this specification for the range of waste types, in the WQR. The producer shall document in the WQR that the canistered waste forms remain nonexplosive, nonpyrophoric, and noncombustible in the event that the temperature exceeds 400°C. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C.

Compliance Strategy

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. Administrative controls and timely weld closure of the canister will prevent entry of prohibited materials into the canistered waste forms.

Implementation

Borosilicate glass, the WVDP HLW form, is oxidized and is not inherently explosive, pyrophoric, or combustible. It is phase stable up to the glass transition temperature and even at 500°C, will not change into these types of prohibited materials.

Prior to entry into the Vitrification Cell, the canisters, which are specified to be cleaned and degreased by the manufacturer, will be visually inspected to ensure that they do not contain any prohibited materials. Verification that this inspection took place will be recorded in the Production Records for the canister. Permanent weld closure after canister filling will ensure against ingress of explosive, pyrophoric or combustible materials. The reference flow path of the canister in the Vitrification Cell is presented conceptually in the Introduction to this WCP.

Documentation

The WQR will report on the absence of explosives, pyrophorics and combustibles in the canistered waste form. The WQR will also present a detailed canister flow path from the vendor to the Vitrification Cell to on-site interim storage which will show there are no opportunities for these materials to enter the canister.

3.4 Organic Materials Specification

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

Compliance Strategy

Borosilicate glass is an inorganic material. Prior to entry into the Vitrification Facility, the canisters will be visually inspected to ensure that no obvious organic material is present. Administrative controls and permanent weld closure will prevent organics from entering the canister after glass filling.

Implementation

Borosilicate glass is an inorganic material. Sucrose, which is the only significant organic compound expected to be present in the melter feed, will decompose in the melter. Standard test methods for assessing the amount of ash from organic materials, 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 A380. Certification of this will be required from the fabricator (Section 2.2). The receipt of this certification will be recorded in the Production Records. Before use, the canisters will be stored closed, 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.

Administrative steps to control storage of organics in the Vitrification Facility and to ensure that lubricants and fluids from the processing and handling equipment cannot drip or spill into the canisters will be taken. In addition, the use of temporary covers while the canisters are in-cell will preclude the introduction of organics by minimizing the period that canisters are uncovered. Timely weld closure of the canister will further limit the possibility of contaminating the waste glass with organics. Samples of glass shards taken prior to closure will be analyzed for total organic carbon to confirm the absence of organic material in a detectable amount (>10 ppm). Results of these analyses will be documented in the WQR.

Documentation

The WQR will report on the controls that ensure, at most, insignificant quantities of organics being present in the canistered waste form. Analytical test data on simulated glass will be included to demonstrate compliance.

3.5 Chemical Compatibility Specification

The producer shall ensure that the contents of the canistered waste form do not cause internal corrosion of the canister which could adversely affect normal handling, during storage, or during an abnormal occurrence such as a canister drop accident. The producer shall describe the method of demonstrating compliance in the WCP. Interactions between the canister and its contents, including any reaction products generated within the canistered waste form, in the event that the temperature exceeds 400°C, shall be discussed in the WQR. If a canistered waste form exceeds 400°C, it is nonconforming and shall be resolved in accordance with Section 4.0. Data/information reporting in the WQR, during the qualification process, shall be limited to temperatures up to 500°C. shall be discussed in the WQR.

Compliance Strategy

Existing data and calculations will be used to show that the canister does not react with the solidified glass. The moisture content in the canister void space and its potential effect on canister corrosion will be estimated. Controls will ensure that liquid water, a potential corrodent, will not be present within the canistered waste form. It will be concluded that the extent of corrosion is sufficiently low as to not affect the integrity of the canister.

Implementation

Both experimental and theoretical evidence will be presented in the WQR to show that internal corrosion of the canister will be extremely minor as a result of the canister material being in contact with the glass waste form. First, it will be shown that reactions between the molten glass and the 304L stainless steel canister wall during filling are insignificant, a consequence of the short duration that the wall is subjected to elevated temperatures (i.e., less than four hours above 600°C). Secondly, it will be argued on theoretical grounds that no significant chemical interactions would be expected to occur at temperatures up to Tg, the glass transition temperature. Tg is the temperature below which a supercooled liquid structure is "frozen" and behaves as a glassy solid. For WVDP glass, this corresponds to a temperature of about 450°C where the viscosity is approximately 10^{13} poise. Below Tg, crystallization/vitrification reaction kinetics become imperceptibly small, indicating that the rate of molecular or atomic movements are extremely low. Accordingly, chemical reactions between stainless steel and glass, which by necessity require the diffusion of reactants to the glass/metal interface and the diffusion of reaction products away from this interface, would be so slow below Tg as to be nearly immeasurable.

The above theoretical assessment is confirmed experimentally by the preponderance of information collected by other researchers. 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 for periods of 6888 and 8821 hours (McCoy, 1983). It was reported that no significant interaction was detected between a typical borosilicate waste glass and 304L stainless steel, the WVDP canister material. This conclusion is based on a visual examination of the surface of the metal where it had been in contact with the glass, and the weights of the glass and metal before and after the test.

Other waste form-canister material compatibility studies have been conducted by Savannah River Technical Center (SRTC) 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 10,000 hours. 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 (Angerman and Rankin, 1977). 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 20,000 hours (Rankin, 1980).

The effect of radiation on glass/metal reactions is expected to be small. This is because neutron radiation, which could accelerate solid state reactions at conditions near the glass transition temperature by creating vacancies and other defects, is very low in the WVDP waste form. Ionizing gamma and beta radiation could conceivably accelerate reactions at low temperatures between water and the canister (i.e., localized corrosion), but excluding moisture from the sealed canister should minimize these effects.

The presence of liquid water inside the canister could lead to localized corrosion (i.e., stress corrosion cracking) of 304L stainless-steel, especially if Cl^- and F^- leach from the glass). Internal liquid water corrosion, however, will not be a problem at WVDP because weld closure soon after canister filling will prevent the entry of water into the canister during subsequent decontamination and storage operations. Additionally, purging the canister with dry cover gas prior to weld closure may be used to eliminate the possibility of condensation of trapped water vapor inside the canister during storage.

The amount of corrosion that could result from moisture trapped with the air in the canister 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 will be considered. Uniform and nonuniform corrosion such as intergranular corrosion, stress corrosion cracking, and pitting, will be addressed. These calculations will be presented in the WQR and demonstrate that the extent of corrosion is insignificant and therefore does not deleteriously affect the strength and integrity of the canister.

Documentation

The WQR will include an analysis of the extent of corrosion and chemical reactions between the inside of the stainless steel canister, the borosilicate glass waste form and other potential corrodents which may be contained within the sealed canister at temperatures up to 500°C.

3.6 Fill Height Specification

The producer shall fill the canister to a height equivalent to at least 80% of the volume of the empty canister. The producer shall report this height in the Production Records and describe the method of compliance in the WCP. Documentation supporting the selected method of compliance shall be provided in the WQR.

Compliance Strategy

The WVDP plans for its canisters to be 85 percent full. The primary method for determining the fill height of each production canister will be a measuring device which will physically probe the height of the glass in several places. A device that will sit on top of the canister opening and have one or multiple rods that can be independently adjusted to contact the glass surface is being considered. Fill height will be measured after the canister has cooled and been removed from the loading turntable. To assure that final measured height will be within specification limits, at least two in-process methods will be used to determine height while each canister is being filled.

Implementation

The WVDP is planning to fill its canisters to a nominal fill height equivalent of 85 percent of the canister volume with a range of 80 to 95 percent. A measuring rod device will be the method for documenting fill height for the Production Records. A device that can sit on top of the cooled canister opening/flange and have one or multiple rods that can be independently adjusted to contact the glass surface is being designed and will be tested. Glass levels will be determined by subtracting the rod measurement(s) from the total height of the canister minus the thickness of the canister bottom.

In-process methods which will monitor glass level during canister fill and enable WVDP to meet the specified fill height requirements are being developed.

These include, for example:

- Infrared Thermal Imaging - The infrared thermal imaging system operates by remotely measuring the thermal emissions from the canister surface and displaying the output on a high resolution color monitor. The infrared technology is undergoing laboratory tests to demonstrate accuracy; it is expected to be the primary in-process technique for monitoring fill height.

- Melter Transfer Method - Another in-process method for estimating canister fill level will be to record the change in melter level (using dip tube readout) after each transfer to the canister until the canister is full.

Documentation

The WQR will also report on the design of the in-process level detection systems . Results from testing the glass level probe device on non-radioactive glass filled canisters will be provided in the WQR. For each production canister, the fill height as determined by probe measurements will be reported in the Production Records.

3.7 Specification for Removable Radioactive Contamination on External Surfaces

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

In addition, the producer shall visually inspect each canistered waste form and remove visible waste glass from the exterior before shipment. The producer shall describe the method of compliance in the WCP. The producer shall provide the non-fixed radioactive contamination level results in the Storage and Shipping Records.

Compliance Strategy

The canistered waste form will be decontaminated with a nitric acid and Ce^{+4} solution. The WVDP will smear survey the canister's external surfaces according to 10 CFR 71.87(i) before shipout to the repository. The external surfaces of the canistered waste forms will also be visually inspected for visible glass, and if present, the glass will be removed.

Implementation

Before transfer to storage as well as to the repository, the external surface of the canister will be smeared according to the procedure in 10 CFR 71.87(i). It is anticipated that smearing will be done under the lifting flange, along the entire length of the canister body, and on the canister bottom. This procedure may be performed at two separate locations on the canister (about 180 degrees apart) to provide a representative measure of surface contamination. The smears will be counted using standard instruments. The results from each canister, prior to storage, will be recorded in the WVDP internal process log. Before shipout, the smear procedure will be repeated and the smear results will be reported in the Storage and Shipping Records. If any Storage and Shipping Record smear test result exceeds the specified limit, the canister will be decontaminated and smeared again.

The reference decontamination technique for the WVDP canister is immersion in a tank containing nitric acid and Ce^{+4} ions followed by dilute nitric acid rinsing, water washing, and air drying. The process uses an oxidation/reduction system, Ce^{+4}/Ce^{+3}, in a nitric acid solution to chemically remove a thin layer from the stainless steel surface (Bray, 1988). The removal of metal, Me, (and its thin overlying oxide layer) is based primarily on the following reaction:

$$3Ce^{+4} + Me^{0} \rightarrow 3Ce^{+3} + Me^{+3}$$

Typical decontamination process conditions are expected to include reaction temperatures of about 65°C and reactant concentration of 0.005 to 0.06M Ce^{+4} in an approximately 0.5 - 1M HNO_3 solution. Canister contact times with the decontamination solution is expected to be from 6 to 8 hours. This process affords several advantages over other decontamination techniques including:

(1) the process can be run at low temperatures,

(2) Ce^{+4} provides a self limiting attack on the canister,

(3) material removal is expected to be uniform over the entire canister surface,

(4) the process time for decontamination is sufficiently short (~ 7 hours) to not impact canister filling production schedules, and

(5) the process requires a small equipment size envelope.

In this process, spent decontamination solution will be recycled to the vitrification process. Tests using Ce^{+4} are underway and the updated results will be reported in the WQR. The effect on the label will be evaluated during these tests (see Section 2.3). WVDP may also consider, for backup purposes, other decontamination options such as high pressure spraying with water or water-nitric acid mixtures.

Visual inspection of the canisters, either by direct observation through shield windows or via a television camera, will be made before shipout to ensure that no waste glass is adhering to the canister. Glass deposits should be readily visible, especially after canister decontamination, because of the large differences in reflectivity and color between the glass and the stainless steel canister. Since the etched, decontaminated canister is silvery in color (Westerman, 1990), it is unlikely that any sizable thickness of adhering black nuclear waste glass would not be visible against this background. Very thin sections of adhering glass, if present, would appear as heat discolored, unetched regions on the otherwise bright silver colored etched canister surface. The results of the surface inspection will be recorded in the WVDP internal process log. If glass is adhering to the canister before or after decontamination, it will be removed, possibly by use of a needle gun (a remote technique for glass removal will be discussed in the WQR). Smear tests would then be repeated to ensure compliance with the contamination limits.

Documentation

The WQR will detail the Ce^{+4} decontamination method, the amount of canister material removed, and the methods of visually inspecting and removing adhering visible waste glass from the exterior of the canister. The WQR will also discuss the smear procedure to be used to comply with this specification. The smear test results and visual inspection results affirming the absence of adhering glass for each canister will be provided in the Storage and Shipping Records.

3.8 Heat Generation Specification

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

3.8.1 Heat Generation Projections

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

3.8.2 Heat Generation at Year of Shipment

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

Compliance Strategy

The heat generation rate in a canister containing high-level waste will be calculated using the Standardized Computer Analyses for Licensing Evaluation (SCALE) computer codes. The heat generation rate depends on the amount and type of radionuclides contained in the canister and decreases with time as a result of radioactive decay. Data needed to compute heat generation rate in the SCALE code are the concentration of radionuclides in a canister. The source of these data is in WQR Section 1.2.1. Radionuclide concentrations have been established in the WQR and the corresponding heating rates are computed with the SCALE system. A table of heat generation rates as a function of number of years of decay will be produced. The heat generation rate in the year 2015 will be estimated in the WQR and this rate at the time of shipment will be extrapolated from the WQR data.

Implementation

The heat generation rate in a canistered waste form is dependent upon the amount and type of radionuclides in the canister. The estimation of radionuclide inventory in a canistered waste is discussed in Section 1.2.1 and reported in WQR 1.2.1.

Variations in canistered waste form heat generation rate may be expected due to changing radionuclide concentrations over the production campaign. These radionuclide variations could be caused by differing canister fill levels or variations in the waste chemistry, or radionuclide content, as delivered to the Vitrification Facility from the underground waste storage tank. An estimate of the potential range for radionuclide content in the production canisters will be reported in WQR 1.2. This range of canister radionuclide content will be used as the input data for the SCALE code evaluation of canistered waste form heat generation rates and reported in WQR 3.8, indexed for the years 1996, 2015, and 3115.

If the compositional variation during operation exceeds the assumed variation, the maximum heating rate of the canister involved will be adjusted according to the observed data and an addendum to the WQR will be issued.

Documentation

The WQR will include the expected thermal output indexed to 1996, 2015, and 3115 and the range of expected variations for the canistered waste form based on estimates of the radionuclide inventory. If actual chemical analysis data on the WVDP waste is outside the range of projected values, an addendum to the WQR will be issued. The Storage and Shipping Records for each canister will contain the estimated heat generation rate of the canistered waste form.

3.9 Specification for Maximum Dose Rates

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

3.9.1 Projections of Dose Rates

The producer shall report in the WQR the expected values and the range of expected variation for both gamma and neutron dose rates indexed to the year 2015. The producer shall describe the method for demonstrating compliance in the WCP.

3.9.2 Dose Rates at Time of Shipment

The producer shall provide in the Storage and Shipping Records either the calculated or measured values for both gamma and neutron dose rates at the time of shipment for each canistered waste form. The producer shall describe the method of compliance in the WCP.

Compliance Strategy

Projections of gamma dose rates at the surface of high-level waste (HLW) canisters will be made using the Standardized Computer Analysis for Licensing Evaluation (SCALE) system computer codes (Radiation Shielding Information Center (c), 1996). Estimation of radionuclide inventory is described in WQR Section 1.2. The SCALE codes provide the sources of neutron and gamma radiation in the canister based on the type and amount of radionuclides present in the canister. The radionuclides estimated in WQR 1.2 to be present in a canister for the years of 1996, 2015, and 3115 will be used to compute dose rates. Dose rates for the year of shipment (not known at present) will be interpolated from the 1996, 2015, and 3115 data.

Implementation

Variations in dose rates may be expected if the amount of high-level waste in a canister varies. The canisters will be filled normally to 85% of its capacity even though Waste Acceptance Product Specification requires the canister to be filled to a height equivalent at least 80% of its capacity. Accidentally, a canister may be filled to 100% of its volume so that the upper and lower bounds of the radionuclide concentration could be +15% and -5% respectively. These and other variations will be included in the WQR 1.2 estimates of the radionuclides contained in the canistered waste forms.

Gamma and neutron surface dose rates for the canistered waste form depend on the radionuclide inventory and other properties of the glass such as chemical composition and 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 the Standardized Computer Analyses for Licensing Evaluation (SCALE) computer code. The energy dependent flux at the surface of the WVDP canister will be calculated assuming the source to be uniformly distributed inside the canister. The energy dependent neutron and gamma fluxes at the surface will then be converted into their respective dose rates using appropriate conversion factors. The expected dose rate and its variation will be based on the estimated range of radionuclide concentrations in a canister.
Preliminary calculations indicate that the gamma and neutron dose rate of the WVDP canistered waste form are far below the upper limits of this specification. The dose rate at the surface of the canistered waste form is expected to be similar since the entire inventory of high level wastes of WVDP will be homogenized in a single tank, 8D-2. However, small variations due to process fluctuations may be expected; it is estimated that these variations will be less than $\pm$ 15% based on an analysis of simulated feed during the FACTS test runs.

The results of the calculations reported in WQR Section 3.9 will be used to estimate the dose rates at the time of shipment.

Documentation

The expected dose rates and ranges of variation will be reported in the WQR based upon estimates of radionuclide inventory. The calculated dose rates at the time of shipment for each canistered waste form will be reported in the Storage and Shipping Records.

3.10 Subcriticality Specification

The producer shall design a waste form to ensure that, under normal and accident conditions, a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The calculated effective multiplication factor, k_{eff}, shall be sufficiently below unity to show at least a 5% margin after allowing for bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation. The producer shall describe the method of demonstrating compliance in the WCP and provide supporting documentation in the WQR. The WQR shall also include sufficient information on the nuclear characteristics, such as fissile density, of the canistered waste form to enable subcriticality to be confirmed under transportation, storage and disposal conditions.

Compliance Strategy

K_{eff} for the canistered waste will be calculated using the KENO (Greene and Petrie, 1983) computer code. It will be shown that the calculated effective neutron multiplication factor after adjusting for uncertainties in the method of analysis, K_{eff} (which is defined below), is much less than or equal to 0.90.

$$K_{eff(cal)} + 2|\sigma_{cal}| \leq 0.90$$

Where: σ_{cal} is the uncertainty and bias associated with method of calculation

K_{eff} is the calculated effective neutron multiplication factor.

Implementation

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 3.6. These and the canister geometry (Figure 5) will be input to the KENO computer code (Greene and Petrie, 1983). The KENO criticality analysis code will be validated using known experimental data from which the code bias and method uncertainties will be obtained and quantified.

The validation will also include comparison with known methodologies for selected analysis cases consistent with WVDP canistered HLW. The calculated reactivity of the canistered waste form will be shown to be significantly less than or equal to 0.90, including the bias and uncertainties in the methods of analysis [i.e., $K_{eff(cal)} + 2|\sigma_{cal}| \leq 0.90$]. Normal operating conditions as well as accident conditions, credible compositional variations and storage scenarios at WVDP will be considered.

The WQR will report the reactivity for the compositions developed (see Section 1.1.1) that are most likely to be a criticality concern (lowest boron). The amount of fissionable radionuclides used in this analysis will be conservatively based upon a canister with maximum fissionable material loading and lowest possible boron content and will assume the fissionable material is uniformly dispersed in the glass matrix. The fissile quantities (or content) of the canistered waste used for the analyses will be based on the radionuclide inventory estimates (projections) contained in Tables 7-9.

Documentation

The WQR will present analyses showing that the effective multiplication factor of the canistered waste form is much less than 0.90 for conditions likely to be encountered at WVDP. The report will include sufficient information on the nuclear characteristics of the canistered waste form for transportation, storage and repository design purposes.

3.11 Specifications for Weight and Overall Dimensions

The configuration, dimensions, and weight of the canistered waste form shall not exceed the maximum size and weight which can be received, handled, and emplaced in the repository. These parameters shall be controlled as indicated below and shall be documented at the time of shipment. The producer shall describe the method of compliance in the WCP and the basis for compliance in the WQR.

3.11.1 Weight Specification

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

Compliance Strategy

The glass filled canisters will be weighed and the errors estimated before shipment to the repository.

Implementation

The canistered waste forms will be weighed on a scale in the WVDP shipout area prior to shipment to the repository. It is anticipated that the weight of a canister filled to a level of 85% will be about 2100 kg. The scale will be calibrated and the errors recorded. The maximum canistered waste form weight will be less than 2500 kg and this weight will be at approximately midscale. Errors in weight for the range of acceptable fill heights (Section 3.6) in the canister will be estimated.

Documentation

The WQR will report on the scale. Canistered waste form weights and estimated errors will be recorded in the Storage and Shipping Records.

3.11.2 Specification for Overall Dimensions

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

The producer shall estimate in the WQR the minimum canister wall thickness of the filled, decontaminated canister. The producer shall also provide in the WQR an estimate of the amount of canister material that is removed during surface decontamination and the basis for that estimate. The producer shall document the unfilled canister wall thickness in the Production Records.

Compliance Strategy

Canisters filled during nonradioactive testing and during production at West Valley will be inserted into a test cylinder with dimensions, at most, those given in the specification. The minimum canister wall thickness will be determined from ultrasonic measurements taken on canisters filled during nonradioactive FACTS runs minus the 304L material loss due to the WVDP decontamination process. Ultrasonic wall thickness measurements on the as-manufactured canisters will be made.

Implementation

WVDP will procure a stainless steel cylinder gauge with an inner diameter and length at most 64.0 centimeters and 301 centimeters, (corrected to 70°C) respectively. Selected nonradioactive canisters filled during qualification testing and all radioactive waste canisters before shipout will be inserted into this test cylinder to verify that the canister fits without forcing and meets the maximum dimensional specifications. Before insertion into the shipping casks, the waste canisters will be placed on a flat, horizontal surface to assess their ability to stand upright.

The minimum filled canister wall thickness estimate that will be reported in the WQR will account for thickness loss from both the decontamination process and that due to contact and corrosion with glass. This data will be obtained from ultrasonic gauge wall thickness measurements taken on canisters filled with nonradioactive glass during FACTS and then subtracting estimated wall thickness losses due to the WVDP Ce^{+4} decontamination process (Section 3.7) as determined from experimental studies.

Experimental measurements (to be provided in the WQR) indicate that to effect decontamination of the WVDP stainless steel canister using the Ce^{+4} process described in Section 3.7, approximately 10 μm of material needs to be removed . During production, the solution concentration and/or exposure time will be controlled to remove the contamination and an amount of stainless steel within the above range.

Wall thicknesses will be determined on the as-manufactured, unfilled canisters at the time of fabrication. This data will be provided in the Production Records.

Documentation

The WQR will contain details on wall thickness measurements of the as-manufactured canister and estimated minimum wall thicknesses of the filled and decontaminated canister. The effect of Ce^{+4} decontamination on the extent of material removal will also be provided. The wall thickness of each unfilled canister will be included in the Production Records. The Storage and Shipping Records will document all canisters test results from the overall dimensions (cylinder) test and the upright stand test.

3.12 Drop Test Specification

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

Compliance Strategy

The WVDP strategy for compliance with this specification will consist of two approaches; (1) using engineering calculations to form a basis for the conclusion that the reference canister is capable of surviving a 7 meter drop and (2) dropping nonradioactive glass filled canisters to confirm their ability to withstand the required drop.

Implementation

Engineering calculations will be performed using the finite element stress analysis method. A computer model of the filled reference canister will be created and impact analyses will be performed to simulate the required drop test.

In addition, at least three full scale WVDP canisters, filled with nonradioactive glass to about an 85 percent fill height, will be dropped from a height of 7 meters onto a flat, essentially unyielding surface with the center of gravity over the bottom center. This drop orientation has the highest potential drop height during canister handling. It results if the canister is dropped while being unloaded from the transportation cask in such a manner that it falls back into the cask. Prior to the test, the reference lid will be welded to seal the canister. Post-impact leak tests will be conducted using the Helium Mass Spectrometer Leak Testing method in accordance with ASME Boiler and Pressure Vessel Code - Section V, article 10. Strain on the canister in the vicinity of the impact will be characterized.

Documentation

The results of canister finite element impact analyses and the qualification drop tests will be reported in the WQR.

3.13 Handling Features Specification

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

The producer shall design a grapple, suitable for use in loading and unloading a transportation cask with a standard HLW canister at the repository, which satisfies the following requirements:

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

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

(c) ***The grapple shall be capable of engaging and disengaging the canister flange within a right-circular cylindrical cavity with a maximum diameter of 62.5 cm.***

(d) ***The grapple shall be designed to prevent an inadvertent release of a suspended (standard) canistered waste form when the grapple is engaged with the flange.***

The producer shall describe the grapple in the WCP and provide the designs in the WQR.

Compliance Strategy

A flange geometry for the WVDP canister has been designed. A grapple that will couple with this flange and comply with this specification was designed. The grapple has a rated capacity nearly two times that of a completely (100%) full canister and a 5000 lift cycle lifetime.

Implementation

The planned canister lifting flange geometry and grapple is shown in Figures 5 and 7, respectively. The lifting flange for the canisters will be load tested at a load of at least 150 percent of the maximum filled canister weight of about 2400 kg.

A prototypic grapple, fabricated to West Valley specifications by the Bartholomew Company, Inc.* to meet the requirements of WAPS 3.13, has been delivered to WVDP in late 1993 for testing and evaluation. This grapple (Figure 7) has performance features similar to that for the grapple used by DWPF for their operations (Walker, et.al., 1986) and features a fail-safe mechanism that requires a canister to be set down twice before it will release its grip. The grapple has a 4500 Kg rated lift capacity (nearly two times the mass of a fully filled canister) and a design life of 5000 canister lift cycles. The final design and the acceptance test results on the remote grapple selected for WVDP operations will be detailed in the WQR.

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* Westbury, NY

Documentation

The detailed design of the remote grapple and the codes and standards that will be used during its fabrication and the acceptance test results will be provided in the WQR.

4.0 QUALITY ASSURANCE SPECIFICATION (Part 1)

The producer shall establish, maintain, and execute a quality assurance (QA) program that applies to the testing and analysis activities that demonstrate compliance with these EM-WAPS during waste form qualification, production, acceptance, handling, storage, and preparation for shipment. The producer shall impose a QA program consistent with the QA requirements that govern HLW as identified in the RW Quality Assurance Requirements and Description (QARD) (U.S. DOE) and the Civilian Radioactive Waste Management System's Waste Acceptance System Requirements Document (WA-SRD) (U.S. DOE, 1996 (b)).

Compliance Strategy

In compliance with this specification, the West Valley Demonstration Project (WVDP) has developed a Quality Assurance Program which incorporates the applicable requirements of the RW Quality Assurance Requirements and Description (QARD) and the Civilian Radioactive Waste Management System's Waste Acceptance System Requirements Document, WA-SRD, (U.S. DOE, 1996(b)). These requirements are passed down from the Department of Energy's Field Office through the West Valley Project Office. The program is described in a Quality Assurance Program Description (QAPD) and implemented by subtier documents and procedures.

Implementation

The implementation of this strategy consists of three elements. The first is the development of a High Level Waste Quality Assurance Program, and second is the identification of the items and activities to which the program is applicable. The third element is development of methods to utilize data which has been generated prior to implementation of the current QA Program (qualification of existing data).

QA Program Development

The WVDP High-Level Waste Quality Assurance Program is described in the current revision of WVDP-074, "Quality Assurance Program Description for WVDP High-Level Waste Processing," and WVDP-212, "U.S. DOE WVAO High-Level Quality Assurance Program Description." WVDP-212 describes the DOE West Valley Office (DOE-WV) program and describes the West Valley Nuclear Services (WVNS) program. WVNS is the WVDP maintenance and operating contractor.

The WVDP High-Level Waste Quality Assurance Program is based upon the requirements of DOE Order 5700.6c, "Quality Assurance", ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities, and the RW QARD. Implementation of specific applicable requirements of the RW QARD is described in WVDP-074.

The core document of the WVDP Program is the Quality Management Manual (QM). Its purpose is to iterate the requirements for the quality assurance program and to identify the internal organizations responsible for implementing them. These requirements are then implemented by the WVNS procedural system.

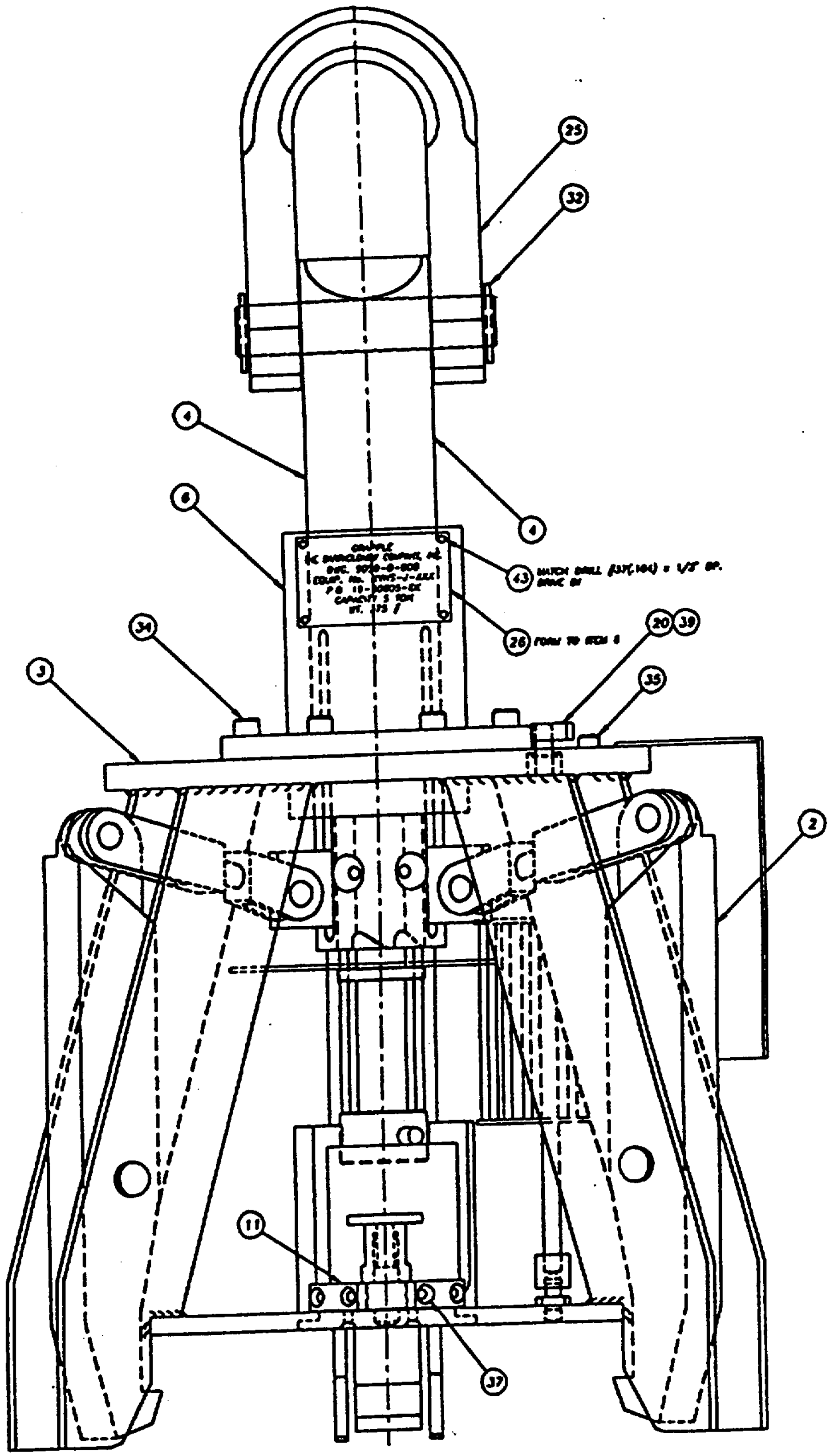

Figure 7

Canister Grapple

WVDP-074 describes the Waste Acceptance Process as consisting of developmental, qualification, production, and storage and shipout activities. The required documentation for the Process is the Waste Form Compliance Plan (WCP), Waste Form Qualification Report (WQR), Production Records, and Storage and Shipping Records.

Identification and Change Control of OCRWM QARD Applicable Items and Activities

The following is the process to identify specific items and activities for which the amplified requirements of the QARD are applicable. First, criteria were established to define those activities which affect the ability to produce a canistered waste form that meets the WAPS requirements. Next, an in-depth review of the WVNS canistered waste form production process, inclusive from waste form development to ship-out, was conducted to determine the activities and their associated equipment that are required to produce a canistered waste form. The above criteria were then applied to those activities and a baseline list, the WVDP HLW Items and Activities List, was developed and included in WVDP-200, "WVDP Waste Acceptance Manual."

The List serves as an internal WVNS reference document as new tasks are initiated. It indicates to an originator whether the task has previously been reviewed for QARD applicability, and the result of that review, i.e., that the requirements of the QARD do or do not apply. As tasks are initiated that do not appear on the baseline list, they are screened for QARD applicability via a process incorporated into WVNS procedures. The List is then revised and issued in accordance with WVNS document control procedures.

The WVDP HLW List is also a central element of WVNS change control for items and activities critical to the Waste Acceptance Process. A proposed change to such an item or activity is reviewed for impact on the process and a determination is made that it is either non-impacting or that additional qualification testing is required prior to implementation of the change. The results of additional qualification testing will be added to the appropriate WQR section, as necessary.

Qualification of Existing Data

There is a body of data germane to compliance with the WAPS that was developed by WVNS prior to the implementation of the current Quality Assurance Program in May, 1989, or developed under Quality Assurance Programs not meeting the requirements of the QARD. This data falls within the scope of "existing data" as defined by the QARD and must be qualified prior to use in support of the Waste Acceptance Process. This data set includes results of work performed both at the WVDP and by WVNS subcontractors.

In order to ensure that the above data is suitable for its intended use, WVNS has established a qualification program incorporating the methods identified in NUREG-1298, 1988, (determination of equivalent controls, corroborating data, confirmatory testing, and peer review) in accordance with the requirements of the QARD Supplement III. The program has been implemented by WVNS departmental procedures and is applicable to data directly required for support of the WQR. This data is identified as WQR Sections are prepared, and placed in data packages which are released for use following completion of an appropriate qualification process.

4.0 QUALITY ASSURANCE SPECIFICATION (PART 2)

The producer shall submit an action plan, signed by authorized personnel, through EM to DOE/RW for correction or disposition of nonconforming waste forms for verification and documented approval from RW. The action plan must identify and describe the nonconformance and any action to change or correct the existing nonconformance.

Compliance Strategy

WVDP shall identify any canistered waste forms that are not in complete compliance with the WAPS, notify the DOE-WV, and submit a plan for disposition of the nonconformance. Following required approvals, the proposed disposition will be implemented and the documentation will be placed in the Production Record for the nonconforming canistered waste form.

Implementation

The possibility exists that some canistered waste forms may not comply in all respects with the WAPS. Within the WVDP, these nonconformances will be identified and documented in accordance with WVDP-002, "Quality Management Manual," QM 15, "Nonconformance Control and Related Activities". Described below is the process by which WVDP will notify appropriate DOE organizations of the existence of a nonconforming canistered waste form and obtain concurrence with a proposed disposition.

1. Subsequent to identification and documentation of the nonconformance(s) in accordance with QM 15, WVDP will notify the DOE-WV, in writing, of a nonconforming canistered waste form, including its unique identification and the specification(s) with which it may not comply. DOE-WV will notify other affected DOE organizations as appropriate.

2. WVDP will then prepare an action plan for the nonconforming canistered waste form, and submit it to DOE-WV for concurrence. The action plan will contain the canister identification, the specification(s) with which it may not comply, a description of the nonconformance, and a proposed disposition that will allow safe shipment and handling of the nonconforming canistered waste form.

3. The DOE-WV will transmit the action plan to the appropriate DOE Operations Office and DOE-EM for required concurrence.

4. WVDP will incorporate any appropriate comments and retransmit the action plan to the DOE-WV.

5. Following formal approval of the action plan, WVDP will implement the proposed disposition, and include documentation of the nonconformance and disposition in the Production Records and/or Storage and Shipping Records as appropriate for the specific canistered waste form.

*5.0 DOCUMENTATION AND OTHER REQUIREMENTS**

5.1 Specification for Waste Acceptance Documentation

The following waste acceptance documentation shall be developed by the waste form producer, maintained as lifetime QA records, and provided to RW:

5.1.1 Waste Form Compliance Plan (WCP)

The WCP shall describe the Producer's plan for demonstrating compliance with the requirements of the EM-WAPS, including a description of tests, analysis and process controls to be performed by the producer and records that will be provided as evidence.

5.1.2 Waste Form Qualification Report (WQR)

The WQR shall compile the results from waste form testing and analysis to demonstrate the ability of the producer to comply with the requirements of the EM-WAPS.

5.1.3 Production Records (PR)

The PR shall describe each canistered waste form through production. Appendix E, contents for HLW Production Records, list the PR table of contents for DWPF and WVDP which have been accepted by EM-32 and the Office of Civilian Radioactive Waste Management. The PR identify the EM-WAPS specifications. (NOTE: The WVDP PR contains additional production data as required by their WQR.)

5.1.4 Storage and Shipping Records

The Storage and Shipping Records shall describe the physical attributes of each canistered waste form and identify any abnormal events, such as thermal excursions, which have occurred during storage.

Compliance Strategy

The WVDP will provide to DOE and maintain as controlled documents the WCP, WQR, Production Records, and Storage and Shipping Records.

Implementation

The Department of Energy has established a Waste Acceptance Process to ensure that glass waste forms will be accepted by the Civilian Radioactive Waste Management System. The present Waste Acceptance Product Specifications (WAPS) were prepared and reviewed by a working group made up of representatives of the repository project and waste form producers. The WAPS require that the WVDP provide the repository program with four types of documentary evidence for acceptance of the WVDP waste form: a Waste Form Compliance Plan, a Waste Form Qualification Report, Production Records, and Storage and Shipping Records. All required documentation will be controlled in

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* In this WCP, only Specification 5.1 will be addressed. The WAPS state that Specification 5.2 - 5.14 are not required to appear in the WCP or WQR.

accordance with the requirements of the DOE RW-0333P (QARD) and WVNS implementing procedures. The WCP and WQR will be reviewed by DOE-WV and DOE-EM prior to transmittal to the Office of Civilian Radioactive Waste Management, RW.

The first form of required documentary evidence is the Waste Form Compliance Plan (WCP). The WVDP WCP provides a strategic description of the methods by which the WVDP will demonstrate compliance with each specification in the WAPS. The WCP contains an Introduction section which reviews the overall history and process that will be used at WVDP to treat the HLW, five sections that detail WVDP's responses to the WAPS, a list of References and an Addendum (glossary) defining terms and acronyms used in the report. The organization of the response sections of the WCP is parallel to that of the WAPS in that the number of a particular specification as given in the WAPS corresponds to the identically numbered section in the WCP. Within each WCP section, the specification number and text is first reproduced verbatim as it appears in the WAPS. This is followed by a brief description (i.e., abstract) of WVDP's Compliance Strategy and a more detailed discussion of that strategy in the Implementation part. Finally, there is a Documentation part which lists the WVDP documents that are required for compliance with that specification and the data that will be contained in those documents.

The second form of required documentation, the Waste Form Qualification Report (WQR), is a compilation of the results of those testing and analysis programs identified in the WCP. The focus of these reports is to confirm and document, in detail, the WVDP's ability to produce an acceptable product that meets specifications. The WQR will be used to gain approval for the start of waste form production at WVDP. The WQR is being prepared in a phased manner and the sections, each corresponding to a specification in the WAPS, will be issued before start-up in a series of packages. The organization of each WQR section will parallel the corresponding section in the WCP and will contain a verbatim restatement of the Specification, WVDP's Compliance Strategy (repeated verbatim from the WCP), a detailed description of WVDP's Implementation and, if appropriate, a part dealing with Documentation that will describe the data to be included in the Production Records and or Storage and Shipping Records.

The Production Records and the Storage and Shipping Records consist of documentation that describe the contents and characteristics of specific individual canistered waste forms. These records, which will be prepared and issued by WVDP, will contain data summarizing the production history of each canistered waste form including canister fabrication, canister filling with glass, weld sealing of the filled canister, storage of the canistered waste form at WVDP to prevent temperature excursions above 400°C, loading into a shipping cask, etc. These controlled documents will be the primary documentary evidence that individual canistered waste forms have satisfied the specifications. The contents of the Production Records and the Storage and Shipping Records are given in Tables 13 and 14, respectively. The Production Records and the Storage and Shipping Records will be provided to DOE.

WVNS has established and maintains a protocol, consistent with the QARD, for administering controlled documents* such as the WCP and WQR. Implementing procedures define the systematic program for the preparation, review, approval, issuance, and revision of controlled documents. As part of this process, the WVNS Records Management Department assigns a unique document identification number, mandates the document format (including revision format), defines who the reviewers of the document can be, and establishes procedures and forms for comments and comment resolution. All appropriate forms, reviewer markups, signatures, and the revised draft document (incorporating resolved comments) must then be returned to Records Management for validation. If acceptable, Records Management then issues the controlled document and maintains the entire procedure package. Controlled documents are also subject to a change control process that defines the format for text revision and procedures for subsequent review, approval, and release; in general, these procedures parallel those for new documents. WVNS procedures define the WVDP WCP and WQR to be controlled distribution documents.

WVNS procedures also describe the actions and activities for controlling the identification, protection, retention, storage, retrieval, and disposal or WVDP records. The WCP, WQR, Production Records, and Storage and Shipping Records will be retained within the Records Program at WVDP and will be categorized as lifetime quality assurance records. Complete lifetime records are documents that, in general, will receive no further entries but whose revision, when required, would be subject to a change control process. These records will be retained for the lifetime of the project and turned over to the DOE and/or the National Archives and Records Administration.

Documentation

The WCP, WQR, Production Records and the Storage and Shipping Records for the high-level waste form will be prepared by the WVDP and provided to the DOE.

6.0 RECORDS MAINTENANCE

No records are generated by this procedure.

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* Controlled documents are documents that specify quality requirements or prescribe activities affecting quality and have traceability from original issue throughout all revisions.

TABLE 13

WAPS REQUIRED CONTENT OF THE PRODUCTION RECORDS*

SPECIFICATION	PRODUCTION RECORD INFORMATION
1.1.2	Chemical analysis of glass shard chemistry (for all elements >0. wt% excluding oxygen)
1.2.2	Estimates of the reportable radionuclide inventory based on analyses of glass shards
1.3, 1.3.1, 1.3.2	Chemical composition of approximately 30 glass shard (see 1.1.2 above) samples (1.3.2), the 95/95 tolerance interval for the corresponding Σ's (1.3.2), the high value for predicted PCT release for B, Li and Na over the glass population (1.3.2), the comparison to the EA value (1.3.2), the predicted PCT results fc B, Li and Na for each of the glass samples (1.3.1), the mean of these predicted PCT results (1.3.1), and the verification of production glass compliance with the specification (1.3)
1.5	A hazardous waste manifest if the waste form is found to be hazardous
2.1	Verification that materials test reports for every canister and its component parts are satisfactory.
2.2	WVNS Certificates of Compliance verifying that canisters were fabricated according to specification, closure weld parameters and visual weld inspection results
2.3.1	Unique identification code for each canister
2.4.1, 2.4.2	As-built length (2.4.1) and diameter (2.4.2) for each canister
3.6	Fill height of each canister
3.11.2	Unfilled canister wall thicknesses
4.0	Nonconforming documentation, if applicable

* This table is not all inclusive but includes only those items mandated by the WAPS. The actual contents of the Production Records will be agreed upon between the EM and RW offices of DOE.

TABLE 14

WAPS REQUIRED CONTENT OF THE STORAGE AND SHIPPING RECORDS*

SPECIFICATION	STORAGE AND SHIPPING RECORD INFORMATION
1.4.2	Certification that the waste form temperature after vitrification has not exceeded 400°C
2.3.1, 2.3.2	Verification of label(s) legibility for each canister
3.7	Smear test results for each canister and verification that no visible glass remains on surface
3.8.2	Estimated heat generation rate
3.9.2	Estimated gamma and neutron dose rates for each canister
3.11.1, 3.11.2	Weight of filled canisters and estimated errors (3.11.1). Verification that canister will stand upright and will fit without forcing into test cylinder (3.11.2)
4.0	Nonconforming documentation, if applicable

* This table is not all inclusive but includes only those items mandated by the WAPS. The actual content of the Storage and Shipping Records will be agreed upon between the EM and RW offices of DOE.

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ADDENDUM 1

GLOSSARY/ACRONYMS

AA - Atomic Absorption Spectroscopy.

Accuracy - The degree to which a value is known with respect to its actual value.

Administrative Controls - managerial methods and procedures used to maintain a particular degree of safety, security, or consistent operation of a process or product.

ANS - American Nuclear Society.

ANSI - American National Standards Institute.

ASME - American Society of Mechanical Engineers.

ASTM - American Society for Testing and Materials.

Batch - a particular volume of feed delivered to the melter at any one time.

Borosilicate Waste Glass - glass typically containing approximately 20 to 40 wt. % waste oxides, 35 to 65 wt. % silica, 5 to 20 wt. % boron oxide, and 10 to 20 wt. % alkali oxides, plus other oxide constituents.

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

Canister Breach - loss of canister leaktightness.

Canistered Waste Form - the waste form in a sealed canister.

Certified Materials - materials that have the required documentation (i.e., certified materials test reports) that their chemical composition/mechanical properties are within the ranges specified by the ASTM. The tests used to obtain the data must conform to the standardized procedures in the relevant ASTM specifications.

CFMT - Concentrator Feed Make-up Tank.

Cold Chemical Main Mix Tank - the mixing vessel designed to combine in proper amounts the non-radioactive raw materials used to blend with the radioactive waste.

Cold Testing - that testing done in/on the completely built Vitrification Facility prior to the addition of radioactive waste materials for the purpose of verification of methods, processes, and procedures.

Combustible Material - any material that can be ignited readily, and when ignited, burns rapidly. Combustible materials are considered to be "chemically reactive."

Controlled Documents - documents that specify quality requirements or prescribe activities affecting quality and have traceability from original issue throughout all revisions; i.e., WCP, WQR.

Corrosiveness - the tendency of a substance to wear away or alter a material by a chemical or electrochemical (essentially oxidizing) process. Corrosive materials are considered to be "chemically reactive."

CPC - Chemical Process Cell of the original NFS plant at West Valley. This cell will be used for interim storage of WVDP production canisters.

CRWMS - Civilian Radioactive Waste Management System.

CUA - Catholic University of America.

Detectable - the limits of equipment and/or ability to measure physical presence.

DOE-WV - DOE West Valley office.

Durability - the ability of a waste form to resist corrosion and/or chemical reaction with foreign materials (such as groundwater); the Product Consistency Test (PCT) is one method of measuring this property. Note that the PCT is a short term (7 day) measure of that resistance.

DWPF - the Defense Waste Processing Facility at Savannah River.

EA Benchmark Glass - that glass composition designed by DWPF which has been cited by the Nuclear Regulatory Commission as being a sufficiently durable waste form.

Expected Process Region - the compositional region around the target glass in which West Valley production glass should lie. More specifically, for the nine dominant glass species, values for the expected process region are: Si: 38.73-43.23 weight percent oxide (WPO); Al: 5.43-6.57 WPO; Zr: 1.12-1.52 WPO; Th: 2.67-4.09 WPO; Na: 7.00-9.00 WPO; K: 4.38-5.63 WPO; Li: 3.25-4.17 WPO; B: 10.96-14.82 WPO; Fe: 10.22-13.82 WPO.

Explosive Material - a substance that, in its normal condition, is characterized by a chemical state that remains unchanged with time, but may be made to undergo rapid chemical change without an outside source of oxygen, whereupon it produces a large quantity of energy generally accompanied by the evolution of hot gases. These substances include those specified in 49 CFR Part 173, Subpart C, Classes A and B.

FACTS - Functional and Checkout Testing of Systems; a full scale series of process tests performed at WVDP between 1984 and 1989.

Free Gas - any gas other than air, including radiogenic gases and cover gases, that could contribute to the pressurization of a canister. This includes gases generated by chemical reaction and radiolytic decomposition.

Free Liquid - liquid that could be drained from the canister either initially or after the canistered waste form has been subjected to temperatures up to 500°C.

Glass Formers - those materials added to the radioactive waste which allow the mixture to form a glass on heating to their melting temperature.

Glass Transition Temperature (Tg) - upon heating, the temperature at which the glass transforms from a rigid solid to a viscous liquid. This temperature corresponds to glass viscosity of about 10^{13} poise, and is usually <500°C for borosilicate waste glasses.

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

GTAW - gas tungsten arc welding.

Hazardous Waste - waste which is defined as hazardous in 40CFR261.3 through 40CFR261.33.

High-Level Radioactive Waste (HLW) - the highly radioactive material resulting from the reprocessing of spent nuclear fuel in defense or commercial facilities, including liquid waste produced directly in the reprocessing operation. For purposes of this document, HLW is vitrified borosilicate glass that has been cast in a stainless steel canister.

ICP-AES - Inductively Coupled Plasma Atomic Emission Spectroscopy.

KENO - a computer code used in the determination of the effective neutron multiplication factor for criticality analysis.

Leaktightness - a leakage rate of 10^{-4}atm-cm^3/sec or less based on dry helium at 25°C and a pressure differential of 1 atm against a vacuum of 10^{-2}atm or less (modified from ANSI N14.5-1987, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials" or ASME's "Boiler and Pressure Vessel Code," Section V, Article 10, Appendix IV (1986)).

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

MFHT - Melter Feed Hold Tank.

Multivariate Analysis - the study of random variables which are multidimensional.

NFS - Nuclear Fuel Services.

95% Confidence Band for the Regression Equation $f(\Sigma,\Sigma^2)$ - a set of two functions $\bar{f}(\Sigma,\Sigma^2)$ and $\underline{f}(\Sigma,\Sigma^2)$ which bound the true value of the regression in the following way:
There is 95% confidence that $\bar{f}(\Sigma,\Sigma^2) \geq f(\Sigma,\Sigma^2) \geq \underline{f}(\Sigma,\Sigma^2)$ holds for every Σ within the domain of the regression.

95% Confidence Interval for the Mean - an interval calculated from the mean and standard deviation of measured values. One can say with 95% confidence that the true mean of the population being measured lies within the 95% confidence interval for the mean.

95/95 Tolerance Interval - an interval calculated from the mean and standard deviation of measured values. One can say with 95% confidence that 95% of the population being measured lies within the 95/95 tolerance interval.

Normalized Release - The measured concentrations of B, Li, or Na in the leachate, from, for example the PCT test, divided by the respective concentrations of these elements in the glass.

NQA-1 - the national standard quality assurance document (issued by ANSI) which provides the basis for the quality assurance systems put in place to oversee the management of high-level radioactive wastes.

Operating Procedures - a series of WVNS-approved written procedures for measuring and recording data necessary for processing the glass waste form; these procedures are controlled by SOP-00-02, "Preparation, Development, and Revision of Standard Operating Procedures (SOP) and Special Instruction Procedures (SIP).

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

ORIGEN2 - a computer code for calculating the buildup, decay, and production of radioactive materials, used for the calculation of radionuclide inventory, dose rates, and heat generation.

PCT - Product Consistency Test; a test of glass durability where a powdered glass is exposed to distilled water at 90°C for seven days; parameters measured are the amounts of certain species (lithium, sodium, and boron) in solution.

PNL - Pacific Northwest Laboratory.

Precision - the degree of agreement among repeated measurements of a quantity.

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

PUREX - a solvent extraction process for removing plutonium and uranium from an aqueous nitrate solution of fission products derived from spent nuclear fuel.

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

QAPD - Quality Assurance Program Description Document.

QARD - Quality Assurance Requirements and Description, DOE/RW-0333P (QARD, 1992).

Qualification Testing - the testing of methods, procedures, and materials to demonstrate compliance with the WAPS.

Radiogenic Gas - any gas produced by radioactive transformation; that is the transmutation of an element into a gaseous element by a change in the atomic nucleus through radioactive decay.

Removable Radioactive Contamination - radioactive material not fixed to a surface. The level of this contamination is determined by wiping an area with an absorbent material, using moderate pressure, and measuring the activity on the wiping material (from 10CFR71.87).

Residuals of Air - components of air present in other than normal proportions.

RW - Department of Energy's Office of Civilian Radioactive Waste Management.

SFCM - Slurry Fed Ceramic Melter.

Secondary Canister - an external containment to enclose a canistered waste form.

Shard - a splinter or chunk of glass removed from the canistered waste form for the purpose of chemical analysis or for archival for later analysis or historic value. These glass fragments routinely break off from the top surface of the canister glass waste form and can be extracted with a vacuum wand.

Sludge - that layer of radioactive waste which has settled to the bottom of the storage tank and has physically separated itself from the liquid.

Storage and Shipping Records - the document that describes the physical attributes of each canistered waste form which is stored at the producer's site and later shipped to the repository. These records also identify any unexpected events, such as thermal excursions, which have occurred during storage.

Strain Point - the temperature at which strains can be relieved in a glass, corresponding to a viscosity of 10^{14} poise.

Target Glass - the glass composition at the center of a range of glasses which have been shown to meet both the Product Consistency (WAPS 1.3) requirement and the WVDP processibility constraints.

TCLP - Toxicity Characteristic Leaching Procedure.

THOREX - a solvent extraction process for removing uranium and/or thorium from an aqueous nitrate solution of fission products derived from spent nuclear fuel or other nuclear materials.

TTT - Time-Temperature-Transformation.

Vitrification Cell/Facility - the building which houses the glass-making operation, including the mixing tanks, feed system, melter, canister handling and decontamination systems, and off-gas treatment system.

WAPS - Waste Acceptance Product Specifications; the technical specification the waste form producers are required to meet in order to ensure acceptance of their vitrified high-level waste into the Civilian Radioactive Waste Management System (CRWMS).

Waste Acceptance - the system element or organization that manages the Accept Waste function which includes acceptance of canistered waste forms into the CRWMS from the producer of such waste.

Waste Form - the radioactive waste materials in a borosilicate glass matrix (10CFR 60.2).

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

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

Waste Type - the waste material (HLW and process recycle streams) fed to each vitrification plant, whose composition and properties will remain relatively constant over an extended period of time during waste form production.

WVDP - West Valley Demonstration Project.

WVNS - West Valley Nuclear Services Co., Inc.