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Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Waste-Form Qualification Compliance Strategy for Bulk Vitrification

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Prepared for the U.S. Department of Energy
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Summary

The Bulk Vitrification System is being pursued to assist in immobilizing the low-activity tank waste from the 53 million gallons of radioactive waste in the 177 underground storage tanks on the Hanford Site. To demonstrate the effectiveness of the bulk vitrification process, a research and development facility known as the Demonstration Bulk Vitrification System (DBVS) is being built to demonstrate the technology. Specific performance requirements for the final packaged bulk vitrification waste form have been identified. In addition to the specific product-performance requirements, performance targets/goals have been identified that are necessary to qualify the waste form but do not lend themselves to specifications that are easily verified through short-term testing. Collectively, these form the product requirements for the DBVS. This waste-form qualification (WFQ) strategy document outlines the general strategies for achieving and demonstrating compliance with the BVS product requirements. The specific objectives of the WFQ activities are discussed, the bulk vitrification process and product control strategy is outlined, and the test strategy to meet the WFQ objectives is described. The DBVS product performance targets/goals and strategies to address those targets/goals are described. The DBVS product-performance requirements are compared to the Waste Treatment and Immobilization Plant immobilized low-activity waste product specifications. The strategies for demonstrating compliance with the bulk vitrification product requirements are presented.

Acronyms

AEA	Atomic Energy Act
AIP	agreement in principle
ALARA	as low as reasonably achievable
ASTM	American Society for Testing and Materials
BV	bulk vitrification
BVS	Bulk Vitrification System
CFR	Code of Federal Regulations
CH2M HILL	CH2M HILL Hanford Group
CIN	container identification number
DBVS	Demonstration Bulk Vitrification System
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HLVIT	high-level vitrification
HSSWAC	*Hanford Site Solid Waste Acceptance Criteria*
FH	Fluor Hanford
ICV™	in-container vitrification
IDF	Integrated Disposal Facility
ILAW	immobilized low-activity waste
LDR	land disposal restrictions
LLBG	low-level burial ground
MCL	maximum concentration limit
PA	performance assessment
PCT	Product Consistency Test
RA	risk assessment
QGCR	qualified glass composition region
RCRA	Resource Conservation and Recovery Act
RD&D	research, development and demonstration
SST	single-shell tank

TCLP	Toxicity Characteristic Leach Procedure
TPA	Tri-Party Agreement
TRU	transuranic
TSD	treatment, storage, and disposal
UTS	Universal Treatment Standard
VHT	Vapor Hydration Test
WAC	Washington Administrative Code
WAP	Waste Analysis Plan
WD/GR	waste disposal/groundwater remediation
WFQ	waste-form qualification
WTP	Waste Treatment and Immobilization Plant

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1.0 Introduction

The U.S. Department of Energy, Office of River Protection (DOE-ORP) has responsibility for managing the safe storage, treatment, and disposal of high-level radioactive waste in underground storage tanks at the Hanford Site in southeastern Washington State. There are 177 underground storage tanks containing 53-million gallons of highly radioactive waste and 190 million curies of radioactivity. This waste was generated primarily as a result of nuclear fuel reprocessing for defense production activities from 1943 to 1989. In 1996, DOE-ORP initiated a project to treat the waste and prepare it for disposal. Subsequently, a team of contractors led by Bechtel National Inc. was selected to design, build, and commission a facility known as the Hanford Tank Waste Treatment and Immobilization Plant (WTP) to treat the tank wastes. To accomplish the waste treatment in the most efficient and safe manner, CH2M HILL Hanford Group (CH2M HILL) is examining supplemental treatment methods. The Bulk Vitrification System (BVS) is being pursued to assist in immobilizing the low-activity tank waste to reduce costs, conserve double-shell tank space, and meet the scheduled tank waste processing completion date of 2028.

To demonstrate the effectiveness of the bulk vitrification (BV) process, a research and development facility known as the Demonstration Bulk Vitrification System (DBVS) is being built to demonstrate the technology using dissolved saltcake waste from Tank 241-S-109. The work will be conducted under a Research, Development, and Demonstration permit issued by the Washington State Department of Ecology (Ecology 2004). Up to 50 BV containers are planned to be prepared during the DBVS demonstration.

The functional, performance, interface, and system design requirements for the DBVS are stated in the DBVS specification (RPP-17403) (CH2M HILL 2004). Included in the specification document are requirements to meet Hanford solid waste disposal facility waste acceptance criteria (HNF-EP-0063) (FH 2004) and specific measurable performance requirements for the final packaged BV waste form. In addition to the specific product performance requirements in the DBVS specification, performance targets/goals have been identified that are necessary to qualify the waste form but do not lend themselves to specifications that are easily verified through short-duration testing. Collectively, these waste acceptance criteria, performance requirements, and performance target/goals form the product requirements for the DBVS.

This waste-form qualification (WFQ) strategy document outlines the general strategies for achieving and demonstrating compliance with the BVS product requirements. This document focuses mainly on the waste products from the DBVS but also establishes an initial WFQ strategy for the future possible BVS. It is the first of several planned documents intended to demonstrate and document that the BV product meets the product specifications (see Figure 1.1[a]). The strategy document will be followed by a waste-

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(a) Figure 1.1 shows the general hierarchy of documents relevant to the bulk vitrification product from the regulatory requirements through to the production documentation. Not shown in the figure are design, testing, process control, and other documentation that take as input the waste-form qualification strategy outlined here. These documents and their relation to the WFQ strategy are important to the success of the bulk vitrification system but are not shown here in order to focus on the WFQ aspects of the documentation. This other important documentation would include, but is not limited to, functional design criteria, engineering design documents, process control plans, sampling and analysis plans, test and campaign plans, and test and campaign reports.

form compliance plan that describes in detail the implementation of the WFQ strategies outlined here. Activities to qualify the BV product before demonstrating treatment with actual waste will be documented in a research, development and demonstration (RD&D) Waste Form Testing report. The actual demonstration will be documented in the RD&D production records. Should the decision be made to fully implement the BVS, an immobilized low-activity waste (ILAW) product qualification document will be prepared to qualify the process for full production. The final product information will be documented in the associated production records.

DOE plans to dispose of the BV containers in Hanford's Integrated Disposal Facility (IDF). The IDF has not established waste acceptance criteria but plans to base its criteria on the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC) (HNF-EP-0063) (FH 2004), supplemented by the *Waste Acceptance Criteria for the Immobilized Low Activity Waste Disposal Facility* (RPP-8402) (Burbank 2002). Because the DBVS specification (RPP-17403) (CH2M HILL 2004) specifies the HSSWAC and because the IDF waste acceptance criteria are expected to be very similar to the HSSWAC, the HSSWAC are used in this WFQ strategy document as the bases for the bulk-vitrification product specifications.

In Section 2 of this WFQ strategy document, the specific objectives of the WFQ activities are discussed, the BV process and product control strategy is outlined, and the test strategy to meet the WFQ objectives is described. Section 3 identifies the DBVS performance targets/goals and describes the strategies to address those targets/goals. Section 4 outlines the DBVS specifications and compares them to the WTP specifications for immobilized low-activity waste. Section 5 then presents the strategies for demonstrating compliance with the specifications for the BV performance.

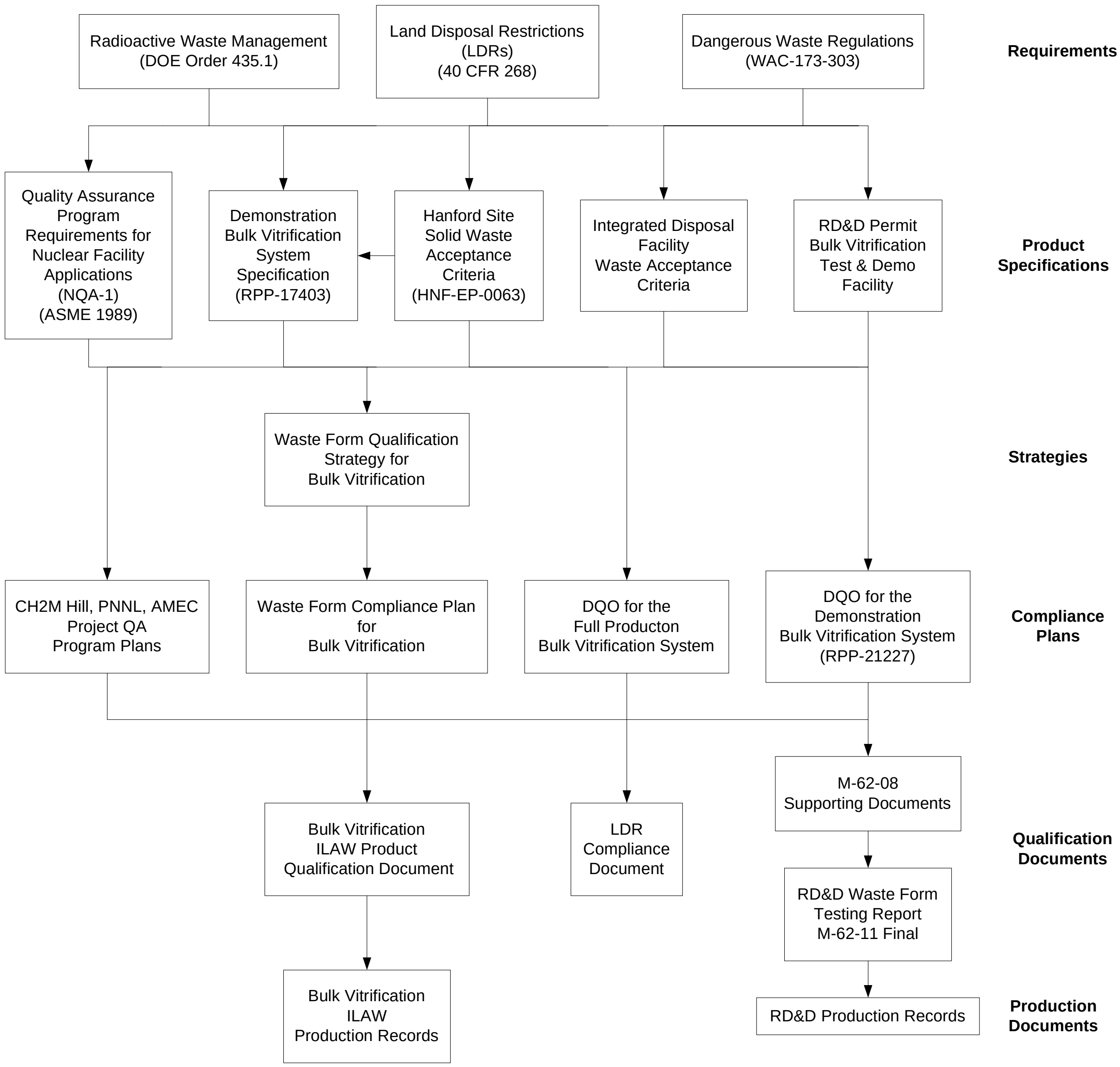

Figure 1.1. Waste-Form Qualification Document Hierarchy for BV

2.0 Waste-Form Qualification Strategy

This section of the strategy describes the general approach used for WFQ. The section discusses the different objectives of the WFQ strategy, the proposed product control strategy for the BV production facility, and the high-level testing strategy that will be used to meet the objectives.

2.1 Objectives and Approach

There are several objectives for WFQ. The first objective is to ensure that the waste packages produced in the operations of the RD&D facility can be disposed of at the Hanford IDF as treated low-activity waste. The second objective of WFQ is to ensure that the necessary data are collected at the required scales to support future milestone decisions and future performance assessments. The third main objective of WFQ is to supply sufficient data to ensure that a production product control strategy can be implemented that is practical for the several thousand waste packages that might be produced while supplying the necessary controls to ensure waste-form quality. Secondary objectives are to provide information to support full BVS production should a decision be made to move forward beyond the RD&D stage. These secondary objectives include verifying the acceptable waste-feed envelope and providing data for complying with land-disposal restrictions. Each of these main and secondary objectives is discussed further in the subsequent sections.

Given the overall objectives of the WFQ strategy, the BV WFQ combines two approaches: one that facilitates initiation of early work to address the most import concerns and a second rigorous approach that ensures that all waste-form requirements are met. The accelerated approach establishes the high-priority objectives and establishes an early testing strategy to address those objectives. The high-priority objectives were developed and documented in the *Draft Test Objectives Table* shown in Appendix A. Appendix B contains the *Bulk Vitrification Test Matrix* that shows all the tests and analytical measurements that were necessary to address the high-priority objectives. Appendix C contains the *Bulk Vitrification Waste Form Test Logic* that shows how all the tests in the test matrix are related and how they meet the early objectives. Appendix D contains the *Bulk Vitrification Waste Form Test Purposes* that describes the purpose for each group of crucible-scale, engineering-scale, and full-scale tests. This accelerated approach has allowed important high-priority work to proceed but could overlook other requirements that might affect BV product acceptance. Therefore, a second parallel approach has been initiated that is based on the WFQ process use for the WTP. This approach establishes a complete list of WFQ requirements and first generates a strategy and then a more detailed plan for complying with each of these requirements. This WFQ strategy has been developed with the accelerated approach in mind but has mainly focused on ensuring that a complete list of requirements is established. After there is general agreement on the strategy, a WFQ plan will be generated that more clearly defines the tests and analyses necessary to meet all requirements. It is expected that the *Bulk Vitrification Test Matrix* shown in Appendix B will address the majority of the testing requirements, but the matrix may need to be updated to include some additional testing as defined in the WFQ plan.

2.1.1 Ensure Disposal of Products from RD&D

One objective of WFQ is to ensure that the RD&D packages are acceptable for final disposal. The operations of the RD&D facility are currently planned to generate up to 50 waste packages using waste feed from Tank 241-S-109. The limited number of packages associated with the RD&D operations and the high sampling frequency anticipated for RD&D waste forms reduce many of the potential difficulties associated with achieving this objective.

The estimated total disposal inventories for key radionuclides in the 50 DBVS packages are very low relative to the total inventories of all tank waste. Even if all the RD&D packages do not meet target levels for waste-form performance for the production facility, the overall inventories are low enough that they should have minimal impact on the performance assessment (PA).

The RD&D packages will be produced to generate data on several different aspects of the BV processing, including product consistency, acceptable operational envelopes, and acceptable variations in waste feed. Sampling and analysis of the RD&D waste packages will also allow demonstration of compliance with land disposal restrictions (LDRs).

Although there are several requirements for disposal of the final waste packages other than LDR compliance and PA performance, many of these requirements are easy to verify and should not represent a major barrier to disposal. In addition, waivers for many of the requirements that do not affect compliance with any applicable regulations or any U.S. Department of Energy (DOE) and/or regulatory agency-approved requirements should be possible for the limited number of packages produced during RD&D operations.

2.1.2 Collect Performance Data to Support M-62-08, M-62-11, and Future PAs

Another objective of WFQ is to supply data to support the decisions associated with the M-62-08[a] and M-62-11[b] Tri-Party Agreement (TPA) milestones (DOE/EPA/Ecology 1988). Although the normal progression of the WFQ process supplies adequate information to determine if the BV process can produce acceptable waste forms, the M-62-08 and M-62-11 are early decision points where the potential success of BV and other supplemental treatment technologies will be evaluated to determine if they can play a role in completing the production mission by 2028 or if a second ILAW facility is required. Where beneficial to support this objective, the WFQ process will adjust early waste simulant testing to supply data for these milestones. These data will help assess the performance of a BV waste form relative to the WTP ILAW product.

WFQ will also need to supply sufficient data to allow future PAs to examine scenarios where a significant fraction of the LAW is treated by BV. The PA requires more data than what is practical to supply on a routine basis to determine the acceptance of individual waste packages. Therefore, WFQ must include data that can be supplied on a routine basis to show compliance with the BV product specifications and more extensive data on some representative BV glass compositions to verify adequate PA performance.

2.1.3 Collect Data to Support Product Control Strategy

Although many of the waste packages produced in the RD&D facility will be sampled, routine sampling of all the BV packages from full production operations would be prohibitively expensive, would require unacceptably high worker safety risk, and would not provide information more accurate than determined through knowledge of the process inputs. Like WTP, the production control strategy for BV would be to

(a) M-062-08, Submittal of Hanford tank waste supplemental treatment technologies report, draft Hanford tank waste treatment baseline and draft negotiations agreement in principle (AIP).

(b) M-062-11, Submit a final Hanford tank waste treatment baseline.

rely on analysis of the waste feed and glass-former materials along with monitoring of critical process-control parameters to predict the final composition of the glass in the BV packages. Glass compositional models generated for BV glasses (and potentially glasses in general) would then be used to verify that the glass in the BV package met the requirements for glass durability. Therefore, another objective of WFQ is to collect the necessary process and product data at various (laboratory through pilot and full) scales to generate and validate the models necessary to support the production product control strategy.

2.1.4 Verify Waste-Feed Envelope

Another objective of WFQ is to determine the boundaries of the waste-feed compositional envelope that is expected to produce acceptable glass. Early WFQ activities will directly support RD&D activities and focus on ensuring that the initial glass formulation will work for any variation expected for retrieved 241-S-109 tank waste. WFQ would then be expanded to determine acceptable glass formulations for the waste-feed envelope anticipated for the BVS.

2.1.5 Comply with Land Disposal Restrictions

Another objective of WFQ is to generate sufficient data to demonstrate compliance with LDR requirements. In addition, if BV is selected for a full production mission, an LDR treatability variance may be needed to ensure LDR compliance while avoiding excessive waste-package sampling and analysis that would be inconsistent with as low as reasonably achievable (ALARA) principles. Therefore, WFQ activities would generate additional data to support an LDR treatability variance.

2.2 Product Process Control Strategy

For the WFQ strategy for the RD&D facility to be effective in capturing the information necessary to support the product control strategy (see Section 2.1.3) for the full production BVS, a more complete discussion of the product control strategy is required. This high-level product control strategy allows all parties involved with the future permitting and operations of a full-scale BVS to agree on an initial concept of how the future BVS will ensure efficient operations that are protective of the environment. The product control strategy presented here may be refined as more information becomes available but captures the current thoughts on how the system will be operated. The interface control points between WTP and BV have not been established, and the interfaces inferred by this product control strategy will need to be addressed and finalized as the product control strategy becomes final.

There are two aspects to ensuring that the immobilized wastes from the BV process meet the product waste acceptance criteria and specifications. Section 2.2 reviews the process-control strategy for actually controlling the waste treatment and immobilization process to achieve the final packaged immobilized waste. Section 2.3 reviews the product qualification strategy for providing the bases for documenting and certifying that the final packaged waste form meets requirements. Process control requires real time process measurements, sampling, and analyses. Product qualification may require more detailed chemical and radiochemical analyses, but the analyses can be completed while the process continues and will be completed before the BV packages are released for disposal.

Figure 2.1 shows a conceptual drawing of the main components and associated sampling locations in a potential BV production facility. Sampling in the RD&D facility will be established to verify the proposed control strategy for the production facility. An early concept for the control strategy is presented below.

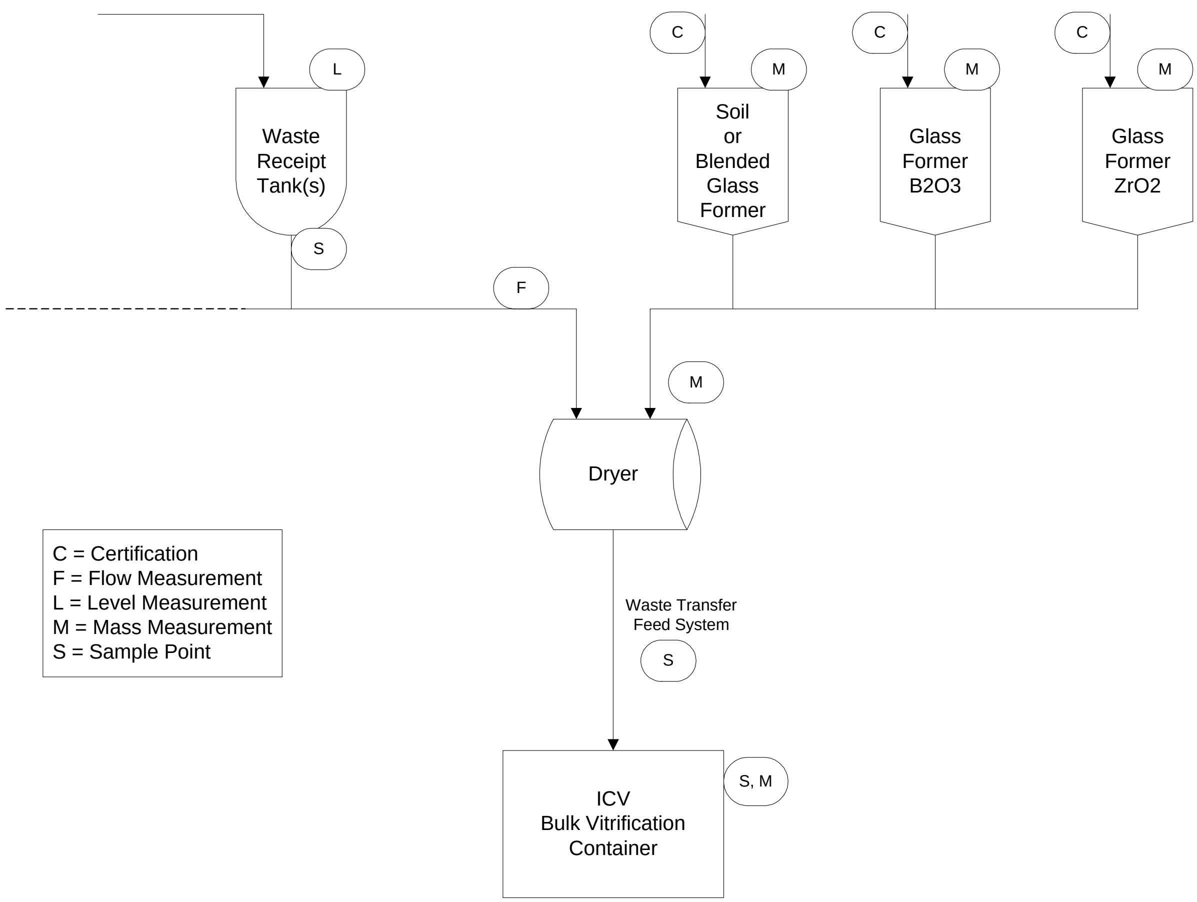

Figure 2.1. Schematic of the Demonstration BV System[(a)]
(ICV™ means in container vitrification.)

2.2.1 Waste-Feed Handling

Conceptually, the production plant will have at least two waste-receipt tanks. At the start of operations, one of the waste-receipt tanks will receive a batch of waste that has previously been determined through sampling and analyses and/or process knowledge to meet the waste-feed specification for the DBVS/BVS system. After receipt of the batch, the tank will be valved out and will receive no additional waste until the entire batch has been processed. The batch will then be sampled, and the samples will be analyzed. Initial analyses will be conducted to confirm that the wastes can be processed through the DBVS/BVS and to determine the quantity of glass-forming materials necessary to produce a glass waste form meeting requirements. Processing will not begin until these initial analyses are completed, or a determination is

(a) Note: The DBVS tanks are agitated through recirculation only and are not on load cells. The need for mixers and load cells for the BVS has not been determined.

made that the existing analyses are valid. While the first tank is being analyzed and processed into glass, the second waste-receipt tank will receive waste for treatment. Once full, the second tank will be capped and treated in the same manner as the first tank. Using this strategy for the feed tanks will allow the production facility to supply a consistent stream of well-characterized waste feed to the BV process.

2.2.2 Glass-Forming Materials

The current glass-forming additives for the BV process include soil, zirconia, and boron oxide. The zirconia and boron oxide will be purchased from qualified vendors that supply the necessary certifications with the material. Confirmatory analyses of the materials may be conducted on a non-routine basis. Soils from onsite, or, if needed, offsite borrow areas will be sampled and analyzed. The number of analyses necessary to characterize the soil will depend on the variability of the soil composition and the sensitivity of waste-form performance to that variability. The glass-forming materials will be stored in tanks, containers, or bulk stockpiles and will be added to the DBVS/BVS treatment systems through hoppers.

2.2.3 Glass Formulation

The quantities of waste feed, soil, and glass formers required to produce a target glass composition will be based on the process-control waste-feed analysis and the soil analysis. These analyses will serve as inputs to a product composition control algorithm and will be used to calculate the amount of each material that needs to be added to each dryer batch.

2.2.4 Dryer Batch Operations

The wastes and glass-forming materials are mixed and dried in a batch-mode rotary mixer dryer. The quantity of waste feed transferred from the waste-receipt tanks will be monitored and controlled through mass flow meters and/or level measurement. The addition of soil and glass formers will be controlled by mass difference measured from the hopper load cells. The dryer will also be on load cells, and the total mass of the added ingredients from the waste tank and feed hoppers will be compared to the total mass indicated by the dryer load cell for comparison. The vacuum dryer will produce a dry granular material composed of dried waste salts, soil, and glass formers. The dried material will be discharged through a waste-feed transfer system into the vitrification system. Approximately eight dryer batches will be required for each BV waste box.

Early DBVS operations will take and analyze samples of each dryer batch to ensure that the correct ratio of waste, soil, and glass formers have been added to the dryer. The anticipated dryer sampling location will be the duct connecting the dryer receiver tank to the dry waste silo. The extent of analyses and the frequency of dried feed samples will be reduced as control charts demonstrate that the feed material analytical data and mass measurements adequately predict the composition of the dried feed. The end goal would be to pull only occasional samples to support process control.

2.2.5 Vitrification Process

An approved BV waste box that contains the starter material (soil and graphite) in the bottom of the box will be prepared in a cold staging facility. The waste box will be moved to the vitrification area where the electrode, offgas, and dried waste-feed connections are made. The first three batches of dried waste feed will be fed into the box, and power will be applied. After melting this initial material, the dried feed material will be metered into the box at a specified rate. The feed rate and total feed added are determined by the load cell on the dried feed hopper. The feed is stopped after the box is filled to the required level, or a predetermined mass addition has been reached. The level will be determined through laser, ultrasonic, thermocouple sensors, visual, or other methods. The box will be held at temperature for the required length of time. If necessary, a fluxing soil will be added to the top of the box to incorporate any non-glassy material. After cooling, soil or other fill material will be added to the top of the box to meet void space requirements, and then the box will be disconnected, closed, and sealed. The box will be moved to a staging area where it is allowed to cool. The box will be released for shipment and disposal after certification waste analysis is available to verify radionuclide content and final glass composition. Early BV boxes may be core drilled to allow glass samples to be taken to verify radionuclide content and glass composition. However, the goal would be to quickly move to a point where the waste, soil, and glass-former input information was used to verify these values with limited glass sampling.

2.3 Qualification of BV Glass Composition

As discussed above, the strategy to control the BV product is to control the immobilization process such that the combination of waste feed and glass-forming materials added to the BV dryer and subsequently to the waste package falls within the range of target compositions established for the waste being processed, with allowance for uncertainty in sampling and analysis. The target compositions will be shown to produce products that can be qualified. Each batch of waste will be mixed with an appropriate amount of soil and glass forming materials to match a target composition in the BV dryer.

A number of glass formulations will be tested to establish a range of BV glass compositions that are compliant with contract specifications. The glass compositions that result in products that meet specifications form a domain identified as the qualified glass composition region (QGCR). To account for variability in the waste composition and uncertainty due to sampling and analysis, an upper and a lower limit will be established for soil and glass-former additions. Figure 2.2 illustrates the concept of the QGCR. The composition of dried waste melter feed must lie within the established bounds to accept the feed for processing. A model to predict the properties of vitrified glass (such as leach resistance) will be developed relating the waste composition to the glass property. Waste-feed compositions will be input to the predictive model to ensure that the vitrified glass can be qualified before transferring the waste from the waste-receipt tanks to the mixer/dryer for processing.

Fully compliant preliminary BV glass formulations have been developed for expected variations in waste feeds from 241-S-109. This was accomplished by first modeling the range of compositions that might be obtained while retrieving 241-S-109 and then conducting a series of crucible tests to determine the acceptable range of formulations. These initial formulations will be used at the start of RD&D testing to determine BV process variability and effects of different waste loadings. BV glass formulations for other waste feeds will also be developed. The range of possible wastes that need to be treated during production operations will be determined by analyzing data from waste retrieval and WTP process models. These data will be used to generate a waste-feed envelope. Simulant crucible tests and limited engineering-scale BV melting tests will be conducted to determine what portion of the envelope can be treated with the existing glass formulations and if additional BV glass formulations are necessary to treat the entire waste envelope. Waste feed from 241-S-109 will be spiked with other chemicals to simulate other portions of the waste feed envelope and then processed in the RD&D facility to validate model results for other portions of the QGCR.

The composition of the BV glass product will be estimated from mass-balance calculations using the detailed chemical and radiochemical analyses of waste samples and the known compositions of the soil and glass-forming materials. Alternately, the composition may be estimated from detailed chemical and radiochemical analyses of samples of the dried blend of waste, soil, and glass formers after passing through the dryer. Glass samples will be taken from early DBVS packages and analyzed to confirm the chemical and radiochemical composition. However, the strategy for documenting and certifying the BV product is to rely on the chemical and radiochemical compositions measured on samples taken upstream of the ICV™ and to use these compositions in the property-composition models to estimate the product-performance properties.

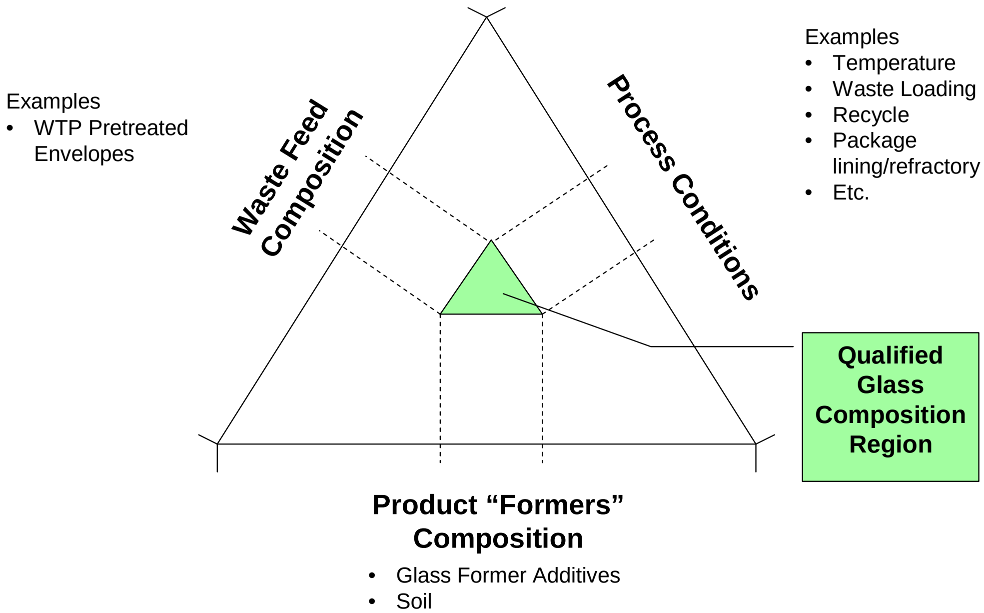

Figure 2.2. Qualified Glass Composition Region as Defined Through Testing of BV Variables

3.0 Performance Targets/Goals

WFQ is a process that ensures the final waste forms meet all requirements for disposal. Many requirements are specific and lend themselves to specific, quantitative requirements that can be measured with specified techniques to demonstrate compliance. For example, the maximum allowable surface dose from a waste package can be specified, and measurement techniques are available to determine if the waste package exceeds these limits. These requirements are discussed in Sections 4 and 5. However, other aspects of an acceptable disposal product are more difficult to quantify. For example, the cumulative long-term impacts of all the waste that will be disposed of in the IDF must not exceed specific dose levels for a specified time period after closing the disposal site. Compliance with this requirement is determined by conducting a PA. The waste-form properties play a significant role in the results of the PA, but a simple test that can accurately predict the long-term performance of a glass has not been developed. Another issue associated with generating specific criteria for BV waste packages is the relationship between required performance and anticipated disposal inventories. Limited disposal operations with low inventory levels will have little effect on the PA regardless of waste-form performance while large inventories must meet more stringent performance requirements. As a result, these kinds of requirements that are difficult to quantify are better addressed by establishing BV waste-form performance targets/goals that help ensure that BV will not prevent an acceptable PA for the IDF.

3.1 Performance Assessment

This section discusses the BV waste performance parameters that are important to support a PA. Important parameters include the amount of soluble technetium (Tc) that remains in the waste package and the quantity of non-glassy material. Other parameters that are not strictly part of WFQ but play an important role in determining the impacts to the PA due to potential impacts to secondary waste streams are the Tc and iodine (^{129}I) glass-retention numbers. These sections discuss approaches for establishing performance targets or goals and the general strategy that will be used to verify that those goals have been met.

3.1.1 Soluble Tc

BV tests conducted at engineering-scale in FY 2003 showed that a few percent of the Tc spiked into the feed volatilized from the glass. The amount that volatilized was significantly less than the volatilization projected for the WTP ILAW, and most of the Tc that volatized from the melt condensed in the off gas pipes or at the off gas filters where it would be available for recycle into subsequent BV melts (Mann et al. 2003; Thompson 2003). However, a small amount of the volatilized Tc condensed in the BV waste package as a soluble salt. Estimates of the quantity of Tc that would condense in a full size box were on the order of 0.3 wt% of the input inventory (McGrail et al. 2003).

A risk assessment (RA) (Mann et al. 2003) of BV waste packages used 0.3 wt% of the Tc inventory as a leachable salt and assumed that 25% of the waste tank Tc inventory is disposed in the IDR. The RA found it sufficient to create a significant peak in the groundwater concentration in a 100-meter down-gradient well (see Figure 3.1). At longer times, after this peak has diminished, the BV package performed as well as WTP ILAW. Although the peak concentrations met regulatory limits, these projected groundwater concentrations could exceed the maximum concentration limit (MCL) under some scenarios considering the uncertainty in the actual Tc salt fraction. BV testing is being conducted to reduce the soluble fraction of Tc in the BV box to ensure that the MCLs are not exceeded. Ideally, the soluble Tc concentration would be reduced to the point that peak groundwater concentrations in the 100-meter down-gradient well do not exceed the highest levels predicted for WTP-produced ILAW, but this a goal and not an absolute requirement.

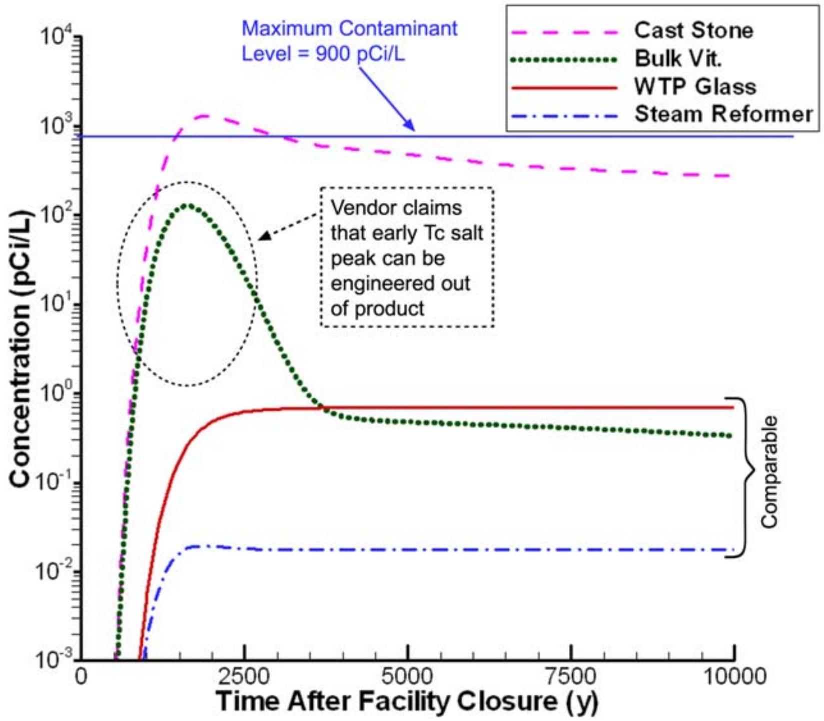

Figure 3.1. Technetium Concentration in 100-Meter Down-Gradient Well (adapted from Mann et al. 2003)

In the current BV package design, there are two main locations where the soluble material condenses: the hood above the glass melt and the castable refractory block used to contain the melt. The relatively small amount of Tc that can be present in a soluble form makes it difficult to establish a test for the final waste package that can conclusively determine the amount of soluble material present in the entire package. Instead, it will be necessary to use a series of laboratory-scale tests to understand the mechanism that leads to the deposit of soluble material. These tests combined with Re- (as a surrogate for Tc) spiked engineering-scale and full-scale simulant tests and Tc-spiked engineering-scale simulant tests will establish where the leachable material tends to form. Destructive analyses of the entire waste package will determine the amount of Re/Tc retained in the glass, the amount of Re/Tc removed by the offgas system, and the amount of soluble material that remains in the waste package on the hood and in the castable refractory block. These destructive tests will also show where the concentrations of soluble Re and Tc are the highest. RD&D testing will proceed after the BV design has been adjusted to control the soluble Tc to acceptable levels. Acceptable levels for the limited inventory that will be disposed of in the RD&D operations will likely be greater than levels expected for production packages. Core sampling of the waste packages produced during the RD&D operations will concentrate on an area of the refractory block where soluble Tc levels were shown to be highest in the Re- and Tc-spiked simulant tests. The RD&D packages will also have provisions to obtain samples from the hood that can be used to verify that soluble Tc on the hood is at acceptable levels. Production operations would rely on the RD&D testing to establish that the BV packages contain acceptable levels of soluble Tc, and only limited sampling of the production packages would be performed for confirmation.

3.1.2 Non-Glassy Materials

Early testing showed that the BV process has the potential to leave some waste material partially reacted. The contaminants in this non-glassy material are more mobile that those incorporated in the glass and could impact the PA results. Subsequent tests have shown that adding some glass-former soil with flux and without any waste material at the end of the BV run will incorporate any non-glassy material into the glass waste form (Thompson 2004). The success of this technique for eliminating non-glassy materials will be verified by destructive analysis of Re-spiked engineering-scale and full-scale simulant tests and Tc-spiked engineering-scale simulant tests.

3.1.3 Technetium and Iodine Retention in Glass

The BV process is expected to retain a large fraction of the Tc in the glass waste form and to capture any Tc that escapes into the off-gas treatment system. The Tc removed in the off-gas system may be recycled in subsequent BV packages. The prior risk assessment (Mann et al. 2003) assumed that none of the ^{129}I remains in the glass and is all captured in the off-gas system, ultimately dispositioned as secondary waste. The partitioning of these key contaminants into either the glass or the secondary waste streams has a significant effect on the results of the risk assessment and PA.

Tests will be conducted to evaluate Tc and ^{129}I retention in the glass matrix. A combination of engineering-scale tests and DBVS tests will provide material balance data for Tc and ^{129}I. Data on retention in the glass will be used in future risk assessment and PA calculations. Results of these tests and calculations will be used to determine appropriate performance targets for Tc and ^{129}I retention in the glass.

3.1.4 Package Performance

The BV waste package contains interface layers that may affect glass performance. Interfaces between the top-off soil and glass and refractory and glass could affect the interface chemistry and glass dissolution rate. Samples of the interface materials from non-radioactive engineering- or DBVS-scale tests will be used in laboratory experiments to investigate these interfaces and provide data for use in future risk assessment and PA calculations. Results of these tests and corresponding risk assessment and/or PA calculations will be used to determine if performance targets for the interface layers are needed.

3.2 Waste Loading/Variability

A goal for BV treatment is to minimize life cycle cost while ensuring adequate waste-form quality. Increased waste loading helps to reduce life-cycle cost. The challenge is to obtain high waste loadings for all feed compositions. The WTP adjusts more than a dozen additives with each feed batch to ensure that they meet or exceed contractual waste-loading requirements. With BV, the strategy is to minimize the additives adjustment to simplify and reduce the cost of process fluctuations while still obtaining high waste loadings. Balancing additives, waste loading, and waste-form quality with varying feed composition to minimize life cycle costs is the challenge for BV. Section 2.3 describes the overall approach to defining a qualified glass-composition region for BV and validating it with DBVS testing.

The results of this testing and analysis will culminate in a process-control model that defines glass-formulation requirements and corresponding product properties given each feed composition. The process-control model will enable analysis and optimization of waste loading and will be used to define waste-loading performance targets, if appropriate, for a BV production facility.

4.0 Specifications

This section of the WFQ strategy document provides a cross reference between the waste-form performance characteristics for the BV waste form and the WTP immobilized low-activity waste-product specifications in the WTP contract statement of work. The BV performance characteristics specifications are delineated primarily in Section 3.2.1, Performance Characteristics of the BV specification (RPP-17403) (CH2M HILL 2004). In addition to the requirements stated directly in the BV specification, Specification 3.2.1.1, *Final Package Waste Form,* also identifies the *Hanford Site Solid Waste Acceptance Criteria* (HNF-EP-0063 Rev 8), Section 2, *General Requirements*, and Section 4, *Acceptance Criteria for the Mixed Waste Disposal Portion of the Low-Level Burial Grounds* (FH 2003) as a source of requirements for the final BV packaged waste form. The WTP contract Specification 2, *Immobilized Low-Activity Waste Product,* provides the requirements for the WTP ILAW product (DOE 2000).

Table 4.1 compares the WTP contract specifications for ILAW based on WTP contract modification M041 with the BV specifications as defined in the BV specification and the HSSWAC. For this comparison, the more recent Revision 10 of the HSSWAC was used. The table is organized by the WTP specifications, providing the title and number of each WTP requirement. The number of the corresponding or similar requirements in the BV and solid waste acceptance criteria are also provided. Table 4.1 then compares the WTP and BV requirements and identifies any actions planned or required to resolve discrepancies between the two sets of requirements. Generally, the specifications for the BV and WTP ILAW product are essentially equivalent. (Note: the subsequent WFQ plan will evaluate the impacts of any requirements changes in the WTP contract the DBVS specification and update the BV WFQ plan accordingly. Also, a cross reference to the Integrated Disposal Facility Waste Acceptance Criteria will be completed when this document is available.)

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Package Description	2.2.2.1	3.2.1.1	2.2; 2.13; 3.5.1; 4.5.1	***WTP***—Sealed stainless steel container enclosing poured glass waste form. ***BV***—Package must be constructed of metal, concrete, or masonry and meet the other requirements in HNF-EP-0063.	No action required. The RD&D testing will produce sufficient data to assess the need for design changes to the production facility waste package. The proposed BV package (i.e., metal roll-off box) will meet these requirements, and is compatible with the IDF design.
Waste Loading	2.2.2.2	None	N/A	***WTP***—Minimum waste Na_2O loadings specified for each of three waste envelopes. ***BV***—No minimum waste loading specified. One purpose of the RD&D BV facility is to gather data to determine a practical waste loading for the BV product. The goal will be to produce as high a waste loading as possible without affecting glass quality.	No action required. The RD&D testing will produce sufficient data to enable evaluation of appropriate waste loading requirements for the BV production facility.
Size and Configuration	2.2.2.3	3.2.1.1	2.13	***WTP***—304 Stainless Steel, right cylinder that is 2.3 M in height and 1.22 M in diameter. ***BV***—Package must meet the requirements in HNF-EP-0063. The proposed BV package (i.e., metal roll-off box) will meet these requirements and is compatible with the IDF design. The proposed BV package is approximately 2.4 M wide × 7.5 M long × 2.9 M high.	No action required. The RD&D testing will produce sufficient data to assess the need for size and configuration design changes to the production facility waste package.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Mass	2.2.2.4	3.2.1.1; 3.2.1.7	2.2	***<u>WTP</u>*—**Mass <10,000 Kgs. For the required disposal package, this mass limits the force exerted by the package to 796 Kg/ft^2. ***<u>BV</u>*—**Mass <85,000 Kgs. Although the mass limitation is higher for BV, force exerted by the anticipated BV package is only 427 Kg/ft^2.	No action required.
Void Space	2.2.2.5	3.2.1.1	4.5.3	Equivalent requirement. ***<u>WTP</u>*—**Void Space <10% at time of filling (void space does not include voids in the glass.) Optional filler if necessary. ***<u>BV</u>*—**Packaged in a form that minimizes subsidence. >90% full when placed in the disposal unit. *Note: WTP requirements have evolved from <1% to <5% and now to <10%, which is consistent with HNF-EP-0063 requirement .*	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Chemical Composition Documentation; Chemical Composition During Production	2.2.2.6; 2.2.2.6.2	3.2.1.1	1.4.4; 2.2; 2.4	***WTP***—The ILAW production documentation shall identify the chemical composition (any elements > 0.5 wt% or required to meet regulatory requirements) of each waste form, optional filler, and package. ***BV***—A detailed record must be kept of the contents, volume, and weight, as well as any added void fillers. Physical and chemical characteristics must be determined to manage the wastes in accordance with the disposal-facility acceptance criteria and applicable regulations and must be recertified annually.	BV project personnel will document the required physical and chemical information in the BV ILAW production records.
Radiological Composition Documentation[(e)]	2.2.2.7	Radiological Composition Documentation is separated into Items 2.2.2.7.1 and 2.2.2.7.2			

(e) Note that source, special nuclear and by-product materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at DOE facilities exclusively by DOE acting pursuant to its AEA authority. These materials are not subject to regulation by the State of Washington under the Washington Hazardous Waste Management Act, the federal Resource Conservation and Recovery Act, or any other relevant provision of law.

Where information regarding processing, packaging, management, and disposal of the radioactive source, byproduct material and/or special nuclear components of mixed waste (as defined by the *Atomic Energy Act of 1954*, as amended) has been provided**,** it is not incorporated for the purpose of regulating the radiation hazards of such components, but is only presented for general knowledge in support of the project discussion.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Radionuclide Composition Qualification	2.2.2.7.1	3.2.1.1, and 3.2.1.9.c	2.2; 2.5	***WTP*—*E***stimated radionuclide concentrations in the waste form shall be identified in the ILAW Product Qualification Report. ***BV*—**DBVS shall be capable of accounting for waste material, including container content. The radionuclide inventory (identification, quantification) for the waste form shall be established. A detailed record must be kept of the contents, volume, and weight, as well as any added void fillers.	BV project personnel will document the required radionuclide concentration information, including radionuclide distribution between product and secondary waste in the BV ILAW qualification document.
Radionuclide Composition During Production	2.2.2.7.2	3.2.1.1	2.2; 2.5	***WTP*—**The ILAW production documentation shall identify the radionuclide inventory in each ILAW package produced. ***BV*—**The radionuclide inventory for the waste form shall be established. A detailed record must be kept of the contents, volume, and weight, as well as any added void fillers.	BV project personnel will document the required radionuclide composition information in the BV ILAW production records.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Radionuclide Concentration Limitations	2.2.2.8	3.2.1.1 and 3.1.2.1.1	4.4.1; 3.4.1; 2.12.2	***WTP***—limited to < Class C, and average of all waste packages limited to Cs < 3 Ci/M^3; Sr < 20 Ci/M^3; ***BV***—limited to < Class C and < 100 nCi/g TRU. Also limited to ≤ 82.5 dose equivalent curies per container (unless evaluations show compliance with safety basis criteria). DBVS further limited by composition of waste feed from S-109. Cs also limited by NRC Incidental Waste Criterion to < .05 Ci/L at 7M Na (DOE/ORP-2003-23, Rev 1) (DOE/ORP 2003).	No action required for the DBVS facility. For the BV Production Facility, the BV requirements are expected to be the same as WTP with average radionuclide concentration limitations for glass produced from WTP-pretreated feed.
Surface Dose Rate Limitations	2.2.2.9	3.2.1.1	4.4.3; 3.4.2; 2.12.4	***WTP***—Surface dose ≤ 500 mRem /hr. ***BV***—Surface dose ≤ 200 mRem /hr and ≤ 100 mRem/hr at 30 centimeters from the waste package. BV specification is more restrictive.	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Surface Contamination Limitations	2.2.2.10	3.2.1.1	2.12.3	***WTP***—Surface contamination ≤ 367 Bq/M^2 alpha (202 dpm/100 cm^2) and 3670 Bq/M^2 beta-gamma (2019 dpm/100 cm^2) when measured with method described in 49 CFR 173.443(a). ***BV***—Surface contamination less than or equal to HNF-5173, Table 2-2. These requirements range from 20 dpm/100 cm^2 to 1,000 dpm/100 cm^2 for alpha, beta, and gamma, depending on the specific isotope (excluding tritium, which has a limit of 10,000 dpm/100 cm^2). BV requirements are more restrictive than WTP requirements.	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Labeling	2.2.2.11	3.2.1.1; 3.3.3.2	2.13.4; Appendix C	Comparable requirement. ***WTP*****—**Unique identification number on each package. Label must remain intact for 50 years in ambient-temperature, ventilated enclosure. ***BV*****—**Unique identification number and bar code on each container. For containers placed in storage, label must remain intact for 20 years. Must meet dangerous waste (WAC 173-303-370)[f] (WAC 2000) labeling requirements.	No action required.
Closure and Sealing	2.2.2.12	3.2.1.1	2.13.1	Comparable requirement. ***WTP*****—**The full loaded package shall be closed and sealed to prevent dispersal of radioactive material. Closure system shall be designed to remain intact for a storage period of 50 years in an ambient-temperature, ventilated enclosure. ***BV*****—**Containers shall maintain containment during handling and storage. Storage period before disposal unspecified.	No action required.

(f) WAC means Washington Administrative Code.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
External Temperature	2.2.2.13	Not specified	Not specified	***WTP*****—**Accessible external surfaces of the package shall not exceed 465°F (alternating pour) or 550°F (single pour) when returned to DOE assuming still air environment at 38°C. ***BV*****—**Not defined	No action required. The external temperature specification is not required for the DBVS system because the facility is designed to store and cool packages until the end of the demonstration. Requirements and/or operating procedures for the full production facility will need to address waste-package temperature compatibility with transportation system, disposal facility, and equipment design.
Free Liquids	2.2.2.14	3.2.1.1	4.2; 4.3.1; 2.4.2	Equivalent requirement. ***WTP*****—**No detectable free liquids per ANSI/ANS-55.1 (ANSI/ANS 1992) or SW-846 Method 9095 . ***BV*****—**All free liquids must be absorbed, stabilized, or otherwise removed from the waste to extent reasonably achievable. Liquid cannot exceed 0.5 vol% per DOE M 435.1-1, Ch. IV, G.1.d.2. The sampling and testing methods outlined in WAC 173 303-110 (WAC 2000) (incl SW 846) must be used for free liquids. *Note: DOE G 435.1-1, Ch. IV also recommends use of ANS-55.1 for testing of stabilized waste forms.*	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Pyrophoricity or Explosivity	2.2.2.15	3.2.1.1	2.3; 4.2	***WTP***—Package not pyrophoric and not capable of detonation or explosion. Waste form and filler not ignitable or reactive. ***BV***—Pyrophoric and explosive wastes, wastes capable of detonation, are not accepted.	No action required.
Explosive or Toxic Gases	2.2.2.16	3.2.1.1	4.2; 2.11.4	***WTP***—Package shall not contain or generate explosive or toxic gases. ***BV***—Package shall not contain or generate toxic gases or gases harmful to long-term stability of disposal site. Provide vents if potential for generating explosive gases.	No action required.
Waste Form Testing	2.2.2.17	Waste Form Testing is separated into Items 2.2.2.17.1 through 2.2.2.17.3.			
Leachability Index	2.2.2.17.1	3.2.1.2.3.4	Explicitly stated in BV specification	***WTP***—This requirement was deleted in Mod 041 of the WTP contract. ***BV***—Requires leachability index greater than 6.0 after 90 days based on ANSI/ANS 16.1 (ANSI/ANS 1986).	BV personnel should evaluate need for ANS/ANSI 16.1 Leachability test for the glass waste forms. Glass waste forms that comply with other specified waste-form requirements have been shown to consistently far exceed the Na leachability index requirement. If necessary, consider limited testing of selected samples to show equivalency to other waste-form performance tests.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Product Consistency Test	2.2.2.17.2	3.2.1.2.2	Explicitly stated in BV specification	Equivalent requirement. ***WTP***—ASTM standard. Na, B, Si normalized mass loss < 2 g/m^2. Specification further communicates that glass samples shall be subjected to representative cooling curves and be statistically representative of the production glass. ***BV***—Specification references newest revision of ASTM standard. Na, B, Si normalized mass loss < 2 g/m^2.	No action required. Samples obtained from the RD&D facility full-scale packages are, due to scale, by definition, representative of the production glass cooling profile. In addition, crucible samples will be subjected to representative cooling profiles.
Vapor Hydration Test	2.2.2.17.3	3.2.1.2.1	Explicitly stated in BV specification	Equivalent requirement. ***WTP***—Glass alteration rate < 50 $g/(m^2\ d)$. References procedure contained within WTP compliance plan. Specification further communicates that glass samples shall be subjected to representative cooling curves and be statistically representative of the production glass. ***BV***— Glass alteration rate < 50 $g/(m^2\ d)$. Specification references procedure documented in the draft ASTM standard rather than WTP compliance plan.	No action required. Samples obtained from the RD&D facility full-scale packages are, due to scale, by definition, representative of the production glass cooling profile. In addition, crucible samples will be subjected to representative cooling profiles.
Compressive Strength	2.2.2.18	3.2.1.2.3	Explicitly stated in BV specification	***WTP***—Mean compressive strength of waste form shall be at least 3.45E6 Pa. ***BV***—Mean compressive strength of waste form shall be at least 3.45E6 Pa.	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Thermal, Radiation, Biodegradation, and Immersion Stability	2.2.2.19	Thermal, Radiation, Biodegradation, and Immersion Stability is separated into Items 2.2.2.19.1 through 2.2.2.19.4 (Note: this requirement was deleted in Mod 041 of the WTP contract.)			
Thermal Degradation	2.2.2.19.1	3.2.1.2.3.1	Explicitly stated in BV specification	***WTP***—This requirement was deleted in Mod 041 of the WTP contract. ***BV***—Compressive strength > 3.45E6 Pa and >75% of initial value after ASTM B553 thermal cycling (ASTM 1979).	BV staff should evaluate the need for these specifications for the BV glass waste form.
Radiation Degradation	2.2.2.19.2	3.2.1.2.3.2	Explicitly stated in BV specification	***WTP***—This requirement was deleted in Mod 041 of the WTP contract. ***BV***—Compressive strength > 3.45E6 Pa and >75% of initial value after 1.0E8 rad dose.	
Biodegradation	2.2.2.19.3	3.2.1.2.3.3	Explicitly stated in BV specification	***WTP***—This requirement was deleted in Mod 041 of the WTP contract. ***BV***—Compressive strength > 3.45E6 Pa and >75% of initial value after ASTM G21 (ASTM 1999) and G22 (ASTM 1976) biodegradation.	
Immersion Degradation	2.2.2.19.4	3.2.1.2.3.4	Explicitly stated in BV specification	***WTP***—This requirement was deleted in Mod 041 of the WTP contract. ***BV***—Compressive strength > 3.45E6 Pa and >75% of initial value after ANSI/ANS 16.1 test (ANSI/ANS 1986).	

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Dangerous Waste Limitations	2.2.2.20	3.2.1.1	2.3; 2.4.2; 2.4.3; 4.2; 4.3.2	***WTP*—**ILAW must be acceptable for land disposal under WAC 173-303 (WAC 2000) and 40 CFR 268. ***BV*—**All waste subject to land disposal restrictions in 40 CFR 268 and WAC 173-303-140 (WAC 2000) shall meet treatment standards. Requirements are equivalent.	No action required.
Compression Testing	2.2.2.21	3.2.1.6	Explicitly stated in BV specification	***WTP*—**Package can withstand compression load of 5× the canister. ***BV*—**Package can withstand compression load of 50,000 kg.	No action required.
Container Material Degradation	2.2.2.22	3.2.1.5	Explicitly stated in BV specification	Equivalent requirement to maintain package integrity for 50 years of storage. WTP contract is more specific with regard to resistance to reasonable degradation mechanisms and environmental conditions during storage. (Note: This requirement was changed in Mod 041 of the WTP contract.)	No action required.
Manifesting	2.2.2.23	3.3.3.2	Explicitly stated in BV specification	Equivalent requirement for dangerous waste package manifesting in accordance with WAC 173-303-370. WTP contract includes requirement for shipping manifest consistent with NUREG/BR-0204 (NRC 1998) and DOE M 435.1-1 (DOE 1999).	No action required. All onsite BV package transportation will comply with Hanford requirements.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Package Handling	2.2.3.1	3.2.1.1	4.5.2; 3.5.2	Equivalent Requirement ***<u>WTP</u>*—**Package shall be equipped with lifting and other handling appurtenances to allow safe lifting and movement when fully loaded. ***<u>BV</u>*—**Packages must be configured for safe unloading by forklift, crane, or alternate means. Packages shall be equipped with a lifting system if designed for unloading by crane.	No action required.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Quality Assurance	2.3	SOW Requisition #: 00105045 Section 7.3, 7.5	2.4; 2.4.2; 2.5	Equivalent requirement ***WTP*—**NQA-1 (1989 Rev.) level QA Program required. Must also address QA/QC requirements of SW-846 and WAC 173-303-806. ***BV***—NQA-1 (1994 Rev.) level compliant QA program required. Sampling and testing methods, including QA requirements, outlined in WAC 173-303-110 (e.g., SW-846) are required. Sufficient sensitivity and accuracy for radiological, physical, and chemical characterization is required to properly designate and manage the waste in accordance with the disposal facility acceptance criteria and all applicable regulations. Waste sampling and analytical work shall comply with DOE/RL-96-68 HASQARD.	BV project personnel will define and document a compliant QA program for BV in a project QA plan.
Inspection and Acceptance	2.4, and Specification 13	3.2.1.1	2.8; 2.10	***WTP*—**Product inspection and acceptance process is defined in WTP contract specification 13 for the production operations, referencing the ILAW Product Compliance Plan. ***BV***—Waste product records must be retained and copies transferred to the product acceptance organization.	The WFQ Strategy shall define requirements for a compliance plan and inspection and acceptance process.

Table 4.1. ILAW Specifications Relevant to BV Compliance Strategy

Specification	WTP Contract Reference (M041)	BV Specification Reference (RPP-17403)	Hanford Site Solid Waste Acceptance Criteria (HNF-EP-0063 Rev 10)	Comparison of Specification	Actions
Technetium Retention	None	3.2.1.3	Explicitly stated in BV specification	***WTP*****—**No requirement ***BV*****—**The immobilized fraction of the ^{99}Tc in the waste container must be greater than or equal to 99.98% (to be revised).	Tc retention is identified as a performance target or goal in the draft outline of the WFQ strategy for BV. Therefore, Tc retention may not be required or amenable to a final production facility contract specification. Product qualification activities and results will be needed to evaluate the necessity for and feasibility of production implementation activities to demonstrate compliance.

5.0 Compliance Strategy/Compliance Plan

The BV specifications were identified and evaluated in Section 4.0. Each subsection in this section addresses a single specification and reports the compliance strategy that BV will use to meet that specification. Differences between the compliance strategies for the RD&D and full-scale BV production facility are noted.

This compliance strategy document will serve as the basis for generating the compliance plan. The compliance plan will be structured the same as the compliance strategy. However, additional information will be appended to each subsection to more clearly delineate the specific activities that will be conducted for product qualification.

5.1 Package Description (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.2, 2.13, 4.5.1)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

For all waste, a detail record must be kept of the contents, volume, and weight, as well as any added void fillers, sorbents, stabilizing agents, or solidification agents (DOE M 435.1-1). (HNF-EP-0063, §2.2)

For containerized waste, the container type, weight, internal and external volume, any shielding provided, and the data packaged must be recorded (DOE M 435.1-1). (HNF-EP-0063, §2.2)

The packages for waste shall meet applicable 49 CFR container requirements for the hazard class/division of the waste, except that packaging for onsite transfers under an approved package-specific safety document might be allowed where cost or technical constraints make the use of a DOT-compliant package unfeasible. If the waste does not meet the definition of any DOT hazard class, a container meeting the general requirements of 49 CFR 173.410 is adequate. (HNF-EP-0063, § 2.13.1)

Outer containers shall be in good condition, with no visible cracks, holes, dents, bulges, pit or scale corrosion, or other damage that could compromise container integrity (WAC 173-303-630). Minor external surface rust that can be sanded or brushed off will be acceptable. Containers having some pit or scale corrosion could be acceptable for storage provided the integrity of the container is confirmed. (HNF-EP-0063, § 2.13.2)

Containers must meet one of the following criteria to ensure compliance with LLBG Fire Hazards Analysis. (HNF-EP-0063, § 4.5.1, § 3.5.1)

- Constructed of metal, concrete, or masonry.

The Permitees shall maintain adequate knowledge of any waste to be managed properly by the DBVS Facility before acceptance, after receipt, and during treatment and storage of these wastes. The Permittees will ensure this knowledge through compliance with the requirements of WAC 173-303-300 and with the provisions of the Waste Analysis Plan (WAP), Permit Attachment BB. (Ecology 2004, § II.B.1)

5.1.1 Compliance Strategy

The BV package will consist of a rectangular steel container with a bolted lid. The container is fabricated from A36 structural steel. At the time of disposal, the container will hold insulation, sand, refractory, glass, and soil filler. The BV project strategy for complying with this requirement is to design the BV package to meet applicable 49 CFR container requirements for the hazard class/division of the waste.

5.2 Waste Loading (None)

There are no waste-loading qualification requirements for DBVS operations. Waste-loading requirements may be established for future production operations based on the results of the DBVS operations. See Section 3.2 for discussion of performance targets/goals for waste loading.

5.2.1 Compliance Strategy

The waste loadings obtained during the DBVS operations will be calculated and reported in the production records.

5.3 Size and Configuration (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.13)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

The packages for waste shall meet applicable 49 CFR container requirements for the hazard class/division of the waste, except that packaging for onsite transfers under an approved package-specific safety document might be allowed where cost or technical constraints make the use of a DOT-compliant package unfeasible. If the waste does not meet the definition of any DOT hazard class, a container meeting the general requirements of 49 CFR 173.410 is adequate. (HNF-EP-0063, § 2.13.1)

The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated. (49CFR173.410 (c))

The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect. (49CFR173.410 (d))

5.3.1 Compliance Strategy

A standard BV container is a rectangular box, 24.5 feet (7.5 m) long, 8 feet (2.4 m) wide, and 9.3 feet (2.9 m) high. The box has a ribbed exterior for structural support. The box lid will be designed to minimize the potential for collecting water. Appendix E shows the BV ICV™ container assembly.

5.4 Mass (RPP-17403, 3.2.1.1, 3.2.1.7, HNF-EP-0063, 2.2)

The mass of each fully processed waste container shall be less than 85 metric tons. (RPP-17403, § 3.2.1.7) (Note: Early calculations indicate that this criterion may be increased to 95 metric tons. This requirement will be modified when the increase is finalized and incorporated in RPP-17403.)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

For all waste, a detail record must be kept of the contents, volume, and weight, as well as any added void fillers, sorbents, stabilizing agents, or solidification agents (DOE M 435.1-1). (HNF-EP-0063, §2.2)

For containerized waste, the container type, weight, internal and external volume, any shielding provided, and the data packaged must be recorded (DOE M 435.1-1). (HNF-EP-0063, §2.2)

5.4.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to show, by analysis and weighing during DBVS operations and by weighing during production operations, that the mass of the filled and sealed BV container will not exceed 85 metric tons (93.7 tons, 187,000 pounds). Before production, a maximum container weight will be calculated based on package material properties to demonstrate compliance with the mass requirement. During production, individual containers will be weighed before and after filling to verify compliance and to determine the mass of waste glass.

5.5 Void Space (RPP-17403, 3.2.1.1; HNF-EP-0063, 4.5.3)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

All waste shall be packaged in a form that minimizes settling and subsidence in trenches 31 and 34 to the maximum extent feasible. Containerized waste must be at least 90 percent full when placed in the disposal unit. (HNF-EP-0063, § 4.5.3) (Note: There are early indications that this criterion may be increased to >95%. This requirement will be modified when the increase is finalized and incorporated in RPP-17403.)

5.5.1 Compliance Strategy

The specifications for void space will be achieved by controlling the height to which the container is filled with glass and the mass and angle of repose of the top-off soil. The glass height will be controlled by continuing to add glass/waste feed material until the glass level obtains the required level. The feed rate and total feed added are determined by the load cell on the dried feed hopper. The feed is stopped after the box is filled to the required level, or a predetermined mass addition has been reached. The level will be determined through laser, ultrasonic, thermocouple sensors, visual, or other methods. After cooling, soil or other fill material will be added to the top of the box to meet void space requirements, and then the box will be disconnected, closed, and sealed. The mass of top-off soil will be verified by weighing the package before and after adding the top-off soil.

5.6 Chemical Composition Documentation (RPP-17403, 3.2.1.1; HNF-EP-0063, 1.4.4, 2.2, 2.4)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Generators that wish to ship waste to Hanford Site TSD units shall provide an annual waste forecast. (HNF-EP-063, § 1.4.4)

For all waste, a detail record must be kept of the contents, volume, and weight, as well as any added void fillers, sorbents, stabilizing agents, or solidification agents (DOE M 435.1-1). (HNF-EP-0063, §2.2)

The waste generator must determine the physical and chemical characteristics of the waste with sufficient accuracy and detail to properly designate and manage the waste in accordance with the unit-specific acceptance criteria and all applicable regulations. (HNF-EP-0063, §2.4)

The Permitees shall maintain adequate knowledge of any waste to be managed properly by the DBVS Facility before acceptance, after receipt, and during treatment and storage of these wastes. The Permittees will ensure this knowledge through compliance with the requirements of WAC 173-303-300 and with the provisions of the Waste Analysis Plan (WAP), Permit Attachment BB. (Ecology 2004, § II.B.1)

5.6.1 Compliance Strategy

The strategy for documenting the chemical composition of the BV glass waste form is to identify glass compositions that meet the waste-form specifications, control the composition of the glass waste form by sampling and analyzing the waste received from WTP or tank farms, and adding soil, zirconia, and boron oxide to achieve a glass composition that meets requirements. The final glass waste-form composition will be reported based upon mass-balance calculations using the mass and chemical analyses of the waste and the masses and compositions of the soil, zirconia, and boron oxide. During early DBVS operations, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control and reporting strategy.

The compositions of the other waste-package components, including the container, insulation, refractories, and filler materials, will be reported based upon material certifications received with the procurements and/or direct chemical analyses.

5.7 Radiological Composition Documentation (RPP-17403, 3.2.1.1, 3.2.1.9(c); HNF-EP-0063, 2.2, 2.5)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

For all waste, a detailed record must be kept of the contents, volume, and weight, as well as any added void fillers, sorbents, stabilizing agents, or solidification agents (DOE-M 435.1-1).

The major radionuclides in the waste and the concentration of each major radionuclide must be established with sufficient sensitivity and accuracy to properly classify and manage the waste in accordance with the TSD unit-specific radiological limits. (HNF-EP-0063, § 2.5)

The DBVS shall be capable of accounting for the waste material received into the DBVS (i.e., mass balance, including waste samples and container content tracking capability). (RPP-17403, §3.2.1.9)

5.7.1 Compliance Strategy

The strategy for documenting the radionuclide inventory of the BV glass waste form is to sample and analyze the waste received from the WTP or tank farms and to calculate the radionuclide inventory based on the radiochemical analyses, the volume of waste, and the amount of soil, zirconia, and boron oxide added to form the glass. Routine radiochemical analyses will determine the concentrations of readily measured radionuclides, and scaling factors will be used to estimate the more difficult to measure radionuclides. The scaling factors will be corroborated periodically with more complete radiochemical analyses of the wastes. During early DBVS operations, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control and reporting strategy.

5.8 Radionuclide Concentration Limitations (RPP-17403, 3.2.1.1, 3.1.2.1.1; HNF-EP-0063, 2.12.2, 4.4.1, 3.4.1)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

The DBVS will receive transfers of low-activity waste from 241-S-109 Waste Retrieval System. (RPP-17403, § 3.1.2.1.1)

Waste must meet the safety basis limit of 82.5 dose equivalent curies per container. Radionuclide quantities greater than 82.5 dose equivalent curies per container may be accepted based on specific container and waste forms but must be evaluated to ensure compliance with safety basis criteria (HNF-15280). HNF-EP-0063, §2.12.2)

The methodology for classification of the radionuclide content of waste according to the various limits listed in the following sections is provided in Appendix A [of HNF-EP-0063]. A waste must meet all of the following conditions to be disposed in the LLBG. (HNF-EP-0063, § 4.4.1, § 3.4.1)

- TRU content limit—TRU content (as calculated by method A1.1 of Appendix A [of HNF-EP-0063]) shall not exceed 100 nanocuries (3700 becquerels) per gram of waste.
- Waste category (as calculated by methods A1.4 and A1.5 of Appendix A [of HNF-EP-0063]) shall not exceed Category 3.

5.8.1 Compliance Strategy

The strategy for complying with the radionuclide concentration limitations is to establish and implement administrative and process controls such that the immobilized waste product limits are never exceeded. A BV waste-feed acceptance specification will be developed that sets maximum radionuclide concentrations in the wastes to be received at the DBVS and full-scale production facilities. Wastes will not be accepted for BV unless the feed specifications are met. Radiochemical analyses of the wastes received from WTP or tank farms will be used to confirm the radionuclide inventory. During early DBVS operations, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control and reporting strategy.

5.9 Surface Dose Rate Limitations (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.12.4, 4.4.3, 3.4.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Waste packages shall not exceed 1 milliSievert per hour (100 millirem per hour) at 30 centimeters (1 foot) from the waste package and 2 milliSieverts per hour (200 millirem per hour) at any point on the surface of the package. Contact handled containers and remote handled containers may be acceptable at the LLBG if the requirements of Section 3.4.2 are met. (HNF-EP-0063, § 2.12.4)

Remote-handled waste is acceptable at the LLBG if approved through both a waste stream profile sheet and a container-specific shipment. Remote-handled waste shall meet the applicable dose rate restrictions of U.S. Department of Transportation (DOT) or an approved package-specific safety document. Remote-handled waste shall be configured for unloading such that personnel exposures are maintained as low as reasonably achievable (ALARA). (HNF-EP-0063, § 4.4.3, § 3.4.2)

5.9.1 Compliance Strategy

The BV project will use a combination of engineering analysis during design and actual measurements during DBVS operations to demonstrate compliance with this requirement. The anticipated maximum radionuclide composition and distribution of the BV package will be used along with information on the geometry of the waste package and thickness and density of shielding materials (e.g., refractory wall) to calculate a maximum surface dose rate for the BV package. Actual measurements of DBVS package surface dose will be made to validate the calculations.

5.10 Surface Contamination Limitations (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.12.3)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Removable contamination on accessible surfaces of the waste package shall not exceed the limits of HNF-5173, Table 2-2. Use of fixatives is not allowed to meet the criteria. (HNF-EP-0063, § 2.12.3)

5.10.1 Compliance Strategy

The BV project’s compliance strategy for this requirement is to swab all containers to determine the level of removable contamination using the method described in 49 CFR 173.443(a). The swabs will be monitored to ensure that removable contamination does not exceed specified limits.

5.11 Labeling (RPP-17403, 3.2.1.1, 3.3.3.2; HNF-EP-0063, 2.13.4, Appendix C)

Any package containing dangerous waste must be labeled and manifested in accordance with WAC 173-303-370, “Manifest System,” and the Dangerous Waste Portion of the Resource Conservation and Recovery Act (RCRA) Permit for the Treatment, Storage, and Disposal of Dangerous Wastes (Permit No. WA 7890008967). (RPP-17403, § 3.3.3.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Packages shall be labeled according to the instructions in Appendix C [of HNF-EP-0063]. (HNF-EP-0063, § 2.13.4)

Containers sent to Hanford Site treatment, storage, and/or disposal units must be labeled for identification and to communicate information needed for proper waste management. Table C-1 [of HNF-EP-0063] shows the standard labeling on containerized waste. The following sections provide general requirements for labels and markings. (HNF-EP-0063, Appendix C)

Each container shall be labeled with a bar code showing the unique container identification number (CIN). (HNF-EP-0063, Appendix C)

Labels and markings must be durable, fade-resistant, water-resistant paints, vinyl stickers, or another system that is sufficiently durable to remain legible during management of the waste before disposal. For waste placed in storage, labels must remain intact and legible for 20 years. (HNF-EP-0063, Appendix C)

Labels and markings shall be positioned so that all required information is visible on the same side of the container as the bar code. (HNF-EP-0063, Appendix C)

Standard labels defined by regulations (e.g., U. S. Department of Transportation [DOT] label, hazardous waste label, polychlorinated byphenyl [PCB] label, asbestos label) should be the conventional size specified by the regulations. Characters on other labels (e.g., gross weight, major risk label) must be a minimum of 2.54 centimeters (1 inch) high. (HNF-EP-0063, Appendix C)

Any package containing dangerous waste must be labeled and manifested in accordance with WAC 173-303-370, "Manifest System," and the Dangerous Waste Portion of the Resource Conservation and Recovery Act (RCRA) Permit for the Treatment, Storage, and Disposal of Dangerous Wastes (Permit No. WA 7890008967).

Pursuant to WAC 173-303-630(3), the Permittees shall ensure that all dangerous and/or mixed waste containers are labeled in a manner that adequately identifies the major risk(s) associated with the contents. (Ecology 2004, § III.D.1)

5.11.1 Compliance Strategy

The BV project compliance strategy for this requirement is to place a label with a unique alphanumeric identification number on the side of each BV package. The label will have a predicted service life of 20 years, assuming that the package is stored in a ventilated enclosure at ambient temperatures. The unique alphanumeric number will be transcribed onto all documentation associated with the BV package. A barcode with the unique container identification number will be applied to each container. Hazard labels will be attached as appropriate.

5.12 Closure and Sealing (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.13.1)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

The packages for waste shall meet applicable 49 CFR container requirements for the hazard class/division of the waste, except that packaging for onsite transfers under an approved package-specific safety document might be allowed where cost or technical constraints make the use of a DOT-compliant package unfeasible. If the waste does not meet the definition of any DOT hazard class, a container meeting the general requirements of 49 CFR 173.410 is adequate. (HNF-EP-0063, § 2.13.1)

Each package used for the shipment of hazardous materials under this subchapter shall be designed, constructed, maintained, filled, its contents so limited, and closed so that under conditions normally incident to transportation –
(1) Except as otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment (49CFR173.24(b))

The package will be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see § §173.24, 173.24a, and 173.24b). (49CFR173.410(f))

5.12.1 Compliance Strategy

The BV package will have a bolted seal with a metal gasket. Visual inspection and swabbing for surface contamination will be used to confirm containment of the vitrified wastes.

5.13 External Temperature (None)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

If heat generation from radiological decay in the waste package exceeds 3.5 watts per cubic meter (0.1 watt per cubic foot), the package must be evaluated to ensure that the heat does not affect the integrity of the container or surrounding containers in storage. (HNF-EP-0063, §2.11.3)

The external temperature specification is not required for the DBVS because the facility is designed to store and cool packages until the end of the demonstration.

5.13.1 Compliance Strategy

Calculations will be performed based on maximum acceptable and typical radionuclide concentrations to confirm that the waste package will not exceed 3.5 watts per cubic meter. Should the heat generation rate exceed 3.5 watts per cubic meter, the design of the BV container to withstand the melting process will be described to demonstrate compliance.

The package will be designed and, once filled, prepared for transport so that in still air at 38°C (100°F) and in the shade, the surface temperature of the package will not exceed 50°C (122°F). The DBVS testing will produce sufficient data to determine the cool-down rates of the BV packages and determine the size of the storage area necessary for the full production facility.

Although the box storage pad of the DBVS is designed to hold all 50 boxes, there may be advantages to shipping some boxes to IDF before the end of the demonstration. BV packages will not be shipped for final disposal unless the surface temperature is below 50°C.

5.14 Free Liquids (RPP-17403, 3.2.1.1; HNF-EP-0063, 4.2; 4.3.1, 2.4.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Liquid low-level waste or low-level waste containing free liquid must be converted into a form that contains as little freestanding liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the waste volume when the low-level waste is in a disposal container, or 0.5 percent of the waste volume after it is processed to a stable form (DOE M 435.1-1, Chapter IV, G.1.d.2) (HNF-EP-0063, §4.2)

All free liquids must be absorbed or stabilized in accordance with Appendix E, or otherwise removed from the waste, except when specifically allowed as follows. (HNF-EP-0063, §4.3.1)

The sampling and testing methods outlined in WAC 173-303-110 must be used for the toxicity characteristics, corrosivity, and free liquids. (HNF-EP-0063, §2.4.2)

5.14.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to show by analysis that the BV drying and vitrification processes remove water from the waste and do not introduce free liquids. Procurement specifications will be developed to ensure that inert filler and containers are received without liquids. Administrative and processing controls will be implemented to ensure that liquids are not added to containers during BV process handling.

5.15 Pyrophoricity or Explosivity (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.3; 4.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

The following waste types are not accepted.

- Explosive waste
- Shock sensitive waste
- Pyrophoric waste
- Class IV oxidizer waste

- Waste that is readily capable of detonation, explosive decontamination, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable (DOE M 435.1-1, Chapters III and IV, N.1) (HNF-EP-0063, §2.3)

Low-level waste must not contain, or be capable of detonation or of explosive decomposition or reaction at anticipated pressures and temperatures, or of explosive reaction with water. Pyrophoric materials contained in the waste shall be treated, prepared, and packaged to be nonflammable (DOE M435.1-1) (HNF-EP-0063, §4.2)

5.15.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to develop the BV final waste form as a silicate glass and to use inert material (such as soil) as the filler. The BV project will show, through analysis, that the ILAW glass and inert material are not ignitable per WAC 173 303 090(5), reactive per WAC 173 303 090(7), or an oxidizer per 49 CFR 173.151. Procurement and handling specifications will be established to ensure that containers are received and handled in a way that prevents contamination by foreign materials.

5.16 Explosive or Toxic Gases (RPP-17403, 3.2.1.1; HNF-EP-0063, 4.2; 2.11.4)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

Low-level waste must not contain, or be capable of generating by radiolysis or biodegradation, quantities of toxic gases, vapors, or fumes harmful to the public or workers or disposal facility personnel, or harmful to the long-term structural stability of the disposal site (DOE M 435.1-1) (HNF-EP-0063, §4.2)

When low-level waste is packaged, vents or other measures shall be provided if the potential exists for pressurizing or generating flammable or explosive concentrations of gases within the waste container (DOE M 435.1-1, Chapter IV, L.1.b). (HNF-EP-0063, §2.11.4)

5.16.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to treat the LAW material to form a silicate glass and to use only inert filler materials known to not generate harmful quantities of explosive or toxic gases, vapors, or fumes at ambient temperatures. The BV project will show by analysis that the ILAW glass and inert filler material are not capable of generating toxic or explosive gases. The BV process will be controlled to prevent any foreign material from entering that could in turn generate explosive or toxic gases.

5.17 Waste Form Testing

5.17.1 Leachability Index (RPP-17403, 3.2.1.2.3.4)

The leachability index shall be greater than 6.0 after immersion for 90 days under the testing condition of ANSI/ANS-16.1, Measurement of Leachability of Solidified Low Level Radioactive Wastes by a Short Term Test Procedure. (RPP-17403, § 3.2.1.2.3.4)

5.17.1.1 Compliance Strategy

The compliance strategy for this requirement is to review and qualify existing data and to perform limited testing, if necessary, to show that the sodium leachability index of the glass waste form satisfies the specification.

5.17.2 Product Consistency Test (RPP-17403, 3.2.1.2.2)

The normalized mass loss of sodium, silicon, and boron shall be less than 2.0 grams/m^2 when measured using a seven-day product consistency test run at 90°C as defined in ASTM C1285-02, Standard Test Methods for Determining Chemical Durability of Nuclear, Hazardous, and Mixed waste Glasses and Multiphase Glass Ceramics. (RPP-17403, § 3.2.1.2.2)

5.17.2.1 Compliance Strategy

The strategy for complying with the Product Consistency Test (PCT) requirement is to produce a glass waste form that has predicted PCT results below the maximum levels specified while still complying with other glass processing and performance requirements to ensure the safe and efficient operation of the BV process. During qualification activities, glass composition regions that meet PCT, Vapor Hydration Test (VHT), waste-loading and glass-processing property requirements will be identified and demonstrated through laboratory- and engineering-scale tests. Correlations will be developed to relate the PCT to the glass composition. During production, controlling the final glass composition will be used to achieve compliance with the PCT requirements.

During DBVS testing, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control. Samples of the early product glass will be tested for PCT to confirm compliance and to demonstrate achieving compliance through glass-composition control.

5.17.3 Vapor Hydration Test (RPP-17403, 3.2.1.2.1)

The glass alteration rate shall be less than 50 grams/(m^2-day) when measured using at least a seven day vapor hydration test run at 200 ºC using the method described in ASTM WK84, Test Method for Measuring Waste Glass Durability by Vapor Hydration Test. . (RPP-17403, § 3.2.1.2.1)

5.17.3.1 Compliance Strategy

The strategy for complying with the VHT requirement is to produce a glass waste form that has predicted VHT results below the maximum levels specified while still complying with other glass-processing and performance requirements to ensure the safe and efficient operation of the BV process. During qualification activities, glass-composition regions that meet PCT, VHT, waste loading, and glass processing property requirements will be identified and demonstrated through laboratory- and engineering-scale tests. Correlations will be developed to relate the VHT to the glass composition. During production, controlling the final glass composition will be used to achieve compliance with the VHT requirements.

During DBVS testing, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control. Samples of the early product glass will be tested for VHT to confirm compliance and to demonstrate achieving compliance through glass-composition control.

5.18 Compressive Strength (RPP-17403, 3.2.1.2.3)

The mean compressive strength of the waste form shall be at least 3.45E6 Pa using the methods of ASTM C39/C39M-01, Standard Test Methods for Compressive Strength Specimens.

5.18.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to use existing data on the compressive strength of nonradioactive glasses to demonstrate that the BV glass compositions will satisfy this requirement.

5.19 Thermal, Radiation, Biodegradation, and Immersion Stability (RPP-17403, 3.2.1.2.3)

The mean compressive strength of the waste form shall be at least 3.45E6 Pa and not less than 75% of the initial compressive strength using the methods of ASTM C39/C39M-01, Standard Test Methods for Compressive Strength Specimens, after subjecting glass samples to the thermal degradation, radiation degradation, biodegradation, and immersion degradation.

- Thermal Degradation (RPP-17403, 3.2.1.2.3.1)
- Thirty thermal cycles between a high of 60ºC and a low of -40ºC in accordance with ASTM B553-79, Test Method for Thermal Cycling of Electroplated Plastics.
- Radiation Degradation (RPP-17403, 3.2.1.2.3.2)
- Exposure to a minimum radiation dose of 1.0E08 rad or to a dose equivalent to the maximum level of exposure expected from self-irradiation during storage, transportation, and disposal if this is greater than 1.0E08 rad.
- Biodegradation (RPP-17403, 3.2.1.2.3.3)
- No evidence of culture growth when representative samples are tested in accordance with ASTM G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi, and ASTM G22-76, Standard Practice for Determining Resistance of Plastics to Bacteria.
- Immersion Degradation (RPP-17403, § 3.2.1.2.3.4)
- The leachability index shall be greater than 6.0 after immersion for 90 days under the testing condition of ANSI/ANS-16.1, Measurement of Leachability of Solidified Low Level Radioactive Wastes by a Short Term Test Procedure.

5.19.1 Compliance Strategy

The BV project's compliance strategy for these requirements is to use available and augmented data (as needed) to show that the BV glass expected to be produced with the DBVS and the production BVS will have mean compressive strength values that satisfy these contract requirements.

5.20 Dangerous Waste Limitations (RPP-17403, 3.2.1.1; HNF-EP-0063, 4.3.2, 2.3, 2.4.2, 2.4.3, 4.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

All waste subject to RCRA LDR (40 CFR 268) and/or Washington State LDR (WAC 173-303-140) must be demonstrated to meet all applicable treatment standards and requirements. For waste that has concentration-based treatment standards for specific hazardous constituent under 40 CFR 268, the waste must be tested at a Hanford Site laboratory or another independent laboratory in accordance with 40 CFR 268. For waste that has treatment standards that are not concentration based, the generator and/or treatment facility must demonstrate that the waste meets the applicable treatment standards using process knowledge and/or by waste analysis, as required by the applicable sections of 40 CFR 268 and WAC 173-303-140. (HNF-EP-0063, § 4.3.2)

The Permittees must meet LDR standards for disposal of final waste forms for waste codes on the SST Part A Permit Application Form 3 as listed in Permit Attachment BB, Table 6-1. All waste forms subject to LDR standards must be demonstrated to meet all applicable treatment standards and requirements (WAC 173-303-140/40 CFR Part 268). Waste that has dangerous and/or mixed waste constituents shall be analyzed in accordance with this Permit and WAC 173-303-140/40 CFR Part 268. Waste that has dangerous/hazardous constituents shall be analyzed in accordance with this Permit and WAC 173-303-140/40 CFR Part 268. For waste that has treatment standards that are not concentration based, the generator and/or treatment facility must demonstrate that the waste meets the applicable treatment standards using process knowledge and/or by waste analysis, as required by the Permit. (Ecology 2004, § II.L.1)

The final vitrified waste will be sampled to provide data for waste form qualification, risk assessment, performance assessment, and regulatory compliance. The vitrified waste will be tested for waste constituents on the SST Part A, which are LDR restricted for disposal in WAC 173-303-104 and 40 CFR 268.40. The constituents analyzed are based on documented process knowledge, analyses of the waste feed, and are reasonably expected to be present in the final waste form. A composited vitrified waste core sample will be analyzed for the dangerous waste constituents that were detected in the tank waste feed to determine compliance with LDR requirements. The frequency of sampling of ICV™ packages will be once for the initial ten (10) packages; subsequent frequency as specified in an Ecology approved WFQ plan. (Ecology 2004, Permit Attachment BB, §6.2.5.1)

5.20.1 Compliance Strategy

The BV program will pursue a two-part approach to demonstrating compliance with the dangerous waste limitations, including land-disposal restriction treatment standards.

In the DBVS, compliance relies on meeting the technology-based standard of high-level vitrification (HLVIT) and on testing, sampling, and analysis to demonstrate compliance to meet concentration-based standards for constituents not associated with HLVIT, i.e., F-listed solvents and certain underlying hazardous constituents. A CH2M HILL Hanford Group, Inc. and DOE/ORP waste form qualification process involving Ecology and the U.S. Environmental Protection Agency (EPA) will include tests at laboratory, engineering, and full-scale with waste simulants supplemented with DBVS test results. This process will determine if BV meets a treatment technology standard of HLVIT. As was the case with the original data submittal from DOE that supported the establishment of HLVIT as the treatment standard for these waste codes, this process will focus on performance of the waste form when tested using the Toxicity Characteristic Leach Procedure (TCLP).[g] For other F-listed organic and inorganic underlying hazardous constituents present in the waste, samples of the waste-package contents will be collected during DBVS production operations and will be submitted to an independent laboratory for TCLP or other appropriate testing to demonstrate that the product meets Universal Treatment Standard (UTS) requirements for LDR.

If selected for low-activity tank waste treatment at Hanford, the production BV operations will pursue a treatability variance to support full production operations. A petition for a treatability variance based on BV will be submitted to Ecology for all concentration-based treatment standards. Obtaining an approved variance will allow production without the requirement for routine testing of the waste product. Laboratory-scale testing results combined with scaled non-radioactive tests will provide the technical support for the treatability variance petition. Selected test(s) will also be conducted to characterize the waste-package contents for regulated organic constituents present in the tank waste to provide a basis for EPA to extend its white paper on organic constituent destruction/removal performance in vitrified glass wastes to include glass produced through BV.[h]

5.21 Compression Testing (RPP-17403, 3.2.1.6)

Each fully loaded package shall be able to withstand a compression load of 50,000 kg with the seal remaining intact. Compliance with this requirement shall be established by using the compression test described in 49 CFR 173.465(d), “Type A Packaging Tests. (RPP-17403, § 3.2.1.6)

5.21.1 Compliance Strategy

The BV project’s compliance strategy for this requirement is to design the constituent parts of the waste package such that the dimensions of the filled package remain within the tolerance range dictated by disposal requirements, and the closure remains intact after it is subjected to the compressive load specified in this requirement. Prototypic BV containers with glass produced from non-radioactive simulant will be tested to demonstrate initial compliance with this requirement. Higher loads will also be tested to determine the available margin for this requirement. One or more BV containers from DBVS will be tested to confirm that the compression load requirement is met.

(g) R. Pelletier. 1989. Docket Number F-89-LD12-FFFFF, (letter to EPA RCRA Docket [OS-305] December 22), U.S. Department of Energy, Washington, D.C.

(h) U.S. Environmental Protection Agency (EPA). 2003. *Hanford Federal Facility Waste Treatment Plant, High-Level Waste Delisting and LDR Compliance White Paper, Organic Constituent Destruction/Removal Performance in Vitrified Glass Wastes*, EPA Region 10, Seattle, WA.

Alternatively, as allowed in 49 CFR 173.461(a), calculations will be used to demonstrate compliance with the compression test design requirements in 49 CFR 173.465(d).

5.22 Container Material Degradation (RPP-17403, 3.2.1.5)

The package shall maintain its integrity during handling and when fully loaded. The package shall maintain its integrity during handling, and transportation, after a storage period of 50 years under the expected storage conditions that may reasonably occur during storage. . (RPP-17403, § 3.2.1.5)

The Permittees shall ensure that all containers used for dangerous and/or mixed waste management are made of or lined with materials which will not react with, and are otherwise compatible with, the waste to be stored. (Ecology 2004, § III.C.2.ix)

5.22.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to fabricate the BV container from steel of the grade, weld material, and wall thickness required to maintain container integrity over 50 years under the expected storage conditions (ambient and ventilated enclosure) and during handling and disposal operations. The container handling features will be designed to enable safe lifting and handling after a storage period of 50 years in an ambient temperature, ventilated enclosure. The container will be designed such that its integrity will not be affected by short-term exposure to wind, blowing sand, precipitation, sunlight, or extreme temperatures.

5.23 Manifesting (RPP-17403, 3.3.3.2)

Any package containing dangerous waste must be labeled and manifested in accordance with WAC 173-303-370, "Manifest System," and the Dangerous Waste Portion of the Resource Conservation and Recovery Act (RCRA) Permit for the Treatment, Storage, and Disposal of Dangerous Wastes (Permit No. WA 7890008967). (RPP-17403, § 3.3.3.2)

5.23.1 Compliance Strategy

The BV project's compliance strategy for this requirement is to provide documentation with each shipment of BV packages that satisfies the requirements of this specification. No offsite shipments of ILAW are anticipated.

The BV project will develop documentation that meets all of the above requirements by using information from the BV production records and supplementing as necessary.

5.24 Package Handling (RPP-17403, 3.2.1.1; HNF-EP-0063, 4.5.2, 3.5.2)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

All packages must be configured for safe unloading by forklift or crane. Alternate means of unloading could be allowed with approval from the TSD unit manager or designee. Packages that must be unloaded by crane shall be equipped with a lifting system designed to safely lift the fully loaded package. All slings and lifting devices shall meet the requirements of the most current version of DOE/RL-92-36. For packages that have special unloading requirements, information must be provided concerning the methods for unloading before shipment is scheduled. Sacrificial rigging shall be provided for remote-handled waste packages. Rigging shall not contain regulated materials, such as lead. (HNF-EP-0063, §3.5.2)

5.24.1 Compliance Strategy

The compliance strategy for this requirement is to design the container to incorporate those features necessary to facilitate safe lifting and movement by crane and to maintain the integrity of the package during these operations.

5.25 Quality Assurance

NQA-1 (1994 Rev.) level compliant QA Program required. Sampling and testing methods, including QA requirements, outlined in WAC 173-303-110 (e.g., SW-846) are required. Sufficient sensitivity and accuracy for radiological, physical, and chemical characterization is required to properly designate and manage the waste in accordance with the disposal facility acceptance criteria and all applicable regulations per HNF-EP-0063, Sections 2.4 and 2.5.

5.25.1 Compliance Strategy

WFQ work will be performed in accordance with a quality assurance plan that implements the requirements of NQA-1 (ASME 1994). Data in support of environmental regulatory activities, including an LDR treatability variance petition, will be collected in accordance with the quality assurance and quality control requirements addressed in SW-846 (EPA 1980) and WAC 173-303-806.

5.26 Inspection and Acceptance (RPP-17403, 3.2.1.1; HNF-EP-0063, 2.8, 2.10)

The DBVS shall produce a final packaged waste form that complies with the Hanford Site Solid Waste Acceptance Criteria, HNF-EP-0063, Sections 2 and 4. (RPP-17403, § 3.2.1.1)

The generator must retain all record copy material used for waste characterization and designation in accordance with federal and state requirements and DOE Orders. These records include process knowledge, sampling information, analytical data, inventory records, and related information. The generator must transfer copies of certain records as requested by the WD/GR Project acceptance organization through the waste acceptance process described on the Hanford Site Solid Waste Acceptance Program internet web page (http://www.hanford.gove/wastemgt/wac). (HNF-EP-0063, §2.8)

A portion of waste containers sent to Hanford Site TSD units must be verified by physical inspection, nondestructive examination, and/or chemical screening as stated in waste analysis plans for the TSD units. For most waste types, this verification can be performed at one of the Hanford Site TSD units. Certain types and configurations of waste, however, cannot be verified easily and could require verification at the generator's location before or during packaging. In these cases, generators must notify the Hanford Site acceptance organization and make verification arrangements before package the waste. This requirement applies to the following types of waste. (HNF-EP-0062, §2.10)

- Shielded waste
- Remote-handled waste
- Waste packaged in containers where the length is greater than or equal to 2.9 meters (9 feet, 6 inches); width at bottom is greater than or equal to 1.61 meters (5 feet, 3.5 inches); width (above 2 feet from bottom) is greater that or equal to 1.93 meters (6 feet 4 inches); and height is greater than 1.64 meters (5 feet 4.75 inches).
- Waste containers weighing more than 3,175 kilograms (7,000 pounds).

5.26.1 Compliance Strategy

The strategy for complying with this requirement is to document the information necessary to show that the BV product conforms to the waste acceptance specifications. A production document associated with each container will be used for this documentation. The production document will summarize the detailed records generated for each package. A waste certification program will be implemented to ensure that the packaged glass waste form meets the waste acceptance criteria.

During early DBVS operations, samples of the dried waste feed and the final glass product will be taken to demonstrate the composition control and reporting strategy.

5.27 Technetium Retention (RPP-17403, 3.2.1.3)

The immobilized fraction of ^{99}Tc in the waste container must be greater than or equal to 99.98% (to be revised.) (RPP-17403, § 3.2.1.3)

5.27.1 Compliance Strategy

Tc retention is identified as a performance target or goal in Section 3.1.1 and 3.1.3 of this strategy. Therefore, Tc retention may not be required or amenable to a final production facility contract specification. Product qualification activities and results will be needed to evaluate the necessity for and feasibility of production implementation activities to demonstrate compliance. See Section 3.1.1 and 3.1.3 for discussion of the WFQ strategy for addressing the Tc retention goals.

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Appendix A

Draft Test Objectives Table

This appendix is Appendix A of the Research, Development, and Demonstration Permit Application, CH2M-0304548, *Draft Test Objectives Table, December 2003*. This table summarizes the test objectives generated from the WFQ meeting held 10/2/03.

Table A.1. Draft Test Objectives Table

				Scale and Testing				Schedule Driver			
								M-62-08	**M-62-11**	**PA**	**Production**
Objective	**Requirements/ Needs**	**Simulant**	**Actual Waste**	**Lab/ Crucible**	**Lab/Eng.-Scale**	**Full-Scale**	**Full-Scale Production (Part B)**	**Jan-05**	**Jan-06**	**Jul-05 PA Submission or Annual Update**	**2010?**
#1. Determine how much and which CoC are not captured in the BV bulk glass	1.C.i Demonstrate tests/design/operational changes, obtain amount, location, and composition of key CoC (non-organics), and confirm release mechanism	S-109 Simulant with Re, I (non-rad), + CoC			Amount, location, and composition of key CoC	Amount and location of key CoC		X		Risk Assessment (12/04)	
		S-109 Simulant with Re, I (non-rad), + CoC and Spiked with Tc			Amount, location, and composition (Tc only) of key CoC			X			
	1.C.ii Demonstrate tests/design/operational changes and obtain amount and location of key CoC (incl. LDR organics, PCBs)	May be addressed through testing or analysis. ?	?			?		? Dependent on FY04 Data/Analysis			
	1.C.iii Demonstrate tests/design/operational changes and obtain amount and location of key CoC (non-organics)		S-109 waste (possibly with Tc spike) with S-109 Simulant to achieve required Na waste loading			Amount, location of key CoC (limited sampling)		X			
	1.D Identify dependence of CoC capture on process and chemistry variables	S-109 Simulant	?		(as needed)	Amount, location of key CoC (limited sampling)				Post FY05 PA Annual Update	X

Appendix A.1. Draft Test Objectives Table (contd)

				Scale and Testing				Schedule Driver			
								M-62-08	**M-62-11**	**PA**	**Production**
Objective	**Requirements/ Needs**	**Simulant**	**Actual Waste**	**Lab/ Crucible**	**Lab/Eng.-Scale**	**Full-Scale**	**Full-Scale Production (Part B)**	**Jan-05**	**Jan-06**	**Jul-05 PA Submission or Annual Update**	**2010?**
#2. Determine understanding and impact of non-bulk glass components (interfaces) of disposal package on performance.	2.A Characterize the breccia and scoria glass properties for larger melt with operational changes	S-109 Simulant (Re)			Same as Full Scale (If required to meet schedule)	Scoria and Breccia connectivity, porosity, density, volume & surface area/volume, composition (incl. CoC)		X		Risk Assessment (12/04	
	2.B Determine impact/significance of breccia and scoria glass on overall BV performance	S-109 Simulant (Re)				SPFT, PCT, PUF		X			
	2.C Confirm breccia and scoria glass properties on actual waste		S-109			Confirmatory with limited core samples. Scoria and Breccia connectivity, porosity, density, volume & surface area/volume, composition (incl. CoC), SPFT, PCT, PUF			X	Confirmatory (7/05 or Annual Update)	

Appendix A.1. Draft Test Objectives Table (contd)

				Scale and Testing				Schedule Driver			
								M-62-08	M-62-11	PA	Production
Objective	**Requirements/ Needs**	**Simulant**	**Actual Waste**	**Lab/ Crucible**	**Lab/Eng.-Scale**	**Full-Scale**	**Full-Scale Production (Part B)**	**Jan-05**	**Jan-06**	**Jul-05 PA Submission or Annual Update**	**2010?**
#3 and #4. Demonstrate Bulk Glass Waste Performance Meets Expectations for Variety of Feed Envelopes and Problem Constituents Representative Waste (e.g., S-109)	3.A.i Define range of impact of potential glass formulations on bulk glass performance for a baseline composition (incl. soil, refractory, waste loading variables)	S-109 Simulant		VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF		VHT, PCT-A, TCLP, limited SPFT, PCT-B		X		X	
	3.A.ii Define range of impact of potential glass formulations on bulk glass performance for a baseline composition (incl. soil, refractory, waste loading variables)		S-109	VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF		VHT, PCT-A, TCLP, limited SPFT, PCT-B		X (subset of tests - VHT, PCT-A, TCLP)		X (full tests if necessary based on comparison of 3.A.i and 3.A.ii VHT, PCT-A results)	
	3.B Identify potential problem consituents and bound composition envelope	S-109 Simulant with bounding consituents *(multiple tests)*		VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF		VHT, PCT-A, TCLP, limited SPFT, PCT-B		X (subset of Lab/ Crucible tests - VHT, PCT-A, TCLP)		X (full tests at full-scale)	
	3.C.i Confirm bounds of composition envelopes - multiple formulations and inclusion of waste treatment options for BoM (e.g., sulfate recycle)	Multiple simulants with bounding consituents *(multiple tests)*		VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF		VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF					X
	3.C.ii Confirm bounds of composition envelopes - multiple formulations and inclusion of waste treatment options for BoM (e.g., sulfate recycle)		Selected tank wastes representative of Env. A, B, C with bounding consituents	VHT, PCT-A, TCLP, limited SPFT, PCT-B, PUF		VHT, PCT-A, TCLP, limited SPFT, PCT-B		X (subset of Lab/ Crucible tests - VHT, PCT-A, TCLP)		X (full tests at Lab and Full-Scale if necessary based on comparison of 3.C.i and 3.C.ii VHT, PCT-A results)	X

Appendix A.1. Draft Test Objectives Table (contd)

				Scale and Testing				Schedule Driver			
								M-62-08	M-62-11	PA	Production
Objective	**Requirements/ Needs**	**Simulant**	**Actual Waste**	**Lab/ Crucible**	**Lab/Eng.-Scale**	**Full-Scale**	**Full-Scale Production (Part B)**	**Jan-05**	**Jan-06**	**Jul-05 PA Submission or Annual Update**	**2010?**
#5. Demonstrate Scale-Up Applicability for Various Scales				Addressed by Requirements/Needs 1.C.i, 2.A, 2.B, and 3.A.i, 3.A.ii, 3.C.i, and 3.C.ii							
#6. Develop Waste Form Qualification Certification/Compliance Process. Demonstrate Ability to Comply with Waste Acceptance Specifications	6.A Develop and Demonstrate Waste Form Qualification Program	Demonstrate necessary feed process control at appropriate scale						WFQ Strategy to support RD&D			Demonstrated WFQ Program
#7. Obtain Additional Testing to Validate/Support Performance Assessment				Addressed by Requirements/Needs 1.C.i, 2.A, 2.B, 3.A.i, 3.A.ii, 3.B, 3.C.i, and 3.C.ii							
#8. Demonstrate that BV Waste Form is as Good as WTP Glass				Addressed by Requirements/Needs 1.C.i, 2.A, 2.B, 3.A.i, 3.A.ii, 3.B, 3.C.i, and 3.C.ii							
#9. Demonstrate effectiveness of representative unit operations and integrated system at appropriate scale	9.A Demonstrate effectiveness of mixer-dryer including i) controlling foaming, and ii) controlling large solids holdup.					X			X		
	9.B Demonstrate effectiveness of representative off-gas system					X			X		

Appendix B

Bulk Vitrification Test Matrix

This appendix is Attachment A to the Developmental Bulk Vitrification System (DBVS) Statement of Work, *Bulk Vitrification Test Matrix, 2/09/04*. This test matrix describes all the tests and analytical measurements that will be conducted to support the WFQ process.

C- Crucible
E- Engineering Scale
FS- Full Scale

FY03: 6-tank composite simulant used for FY03 Decision Process
S109: Baseline S109 Waste
S109(+/-): S109 Envelope
WTP ENV: WTP Pretreated Feed Envelope
TBD: To be determined

Base: Baseline Soil, Additives and Refractory
Soil (+/-): Soil with higher or lower concentrations of some elements
Add (X): Additive X (e.g. ZrO2)
Ref: Refractory

Base: Baseline Method
B-Up: Bottom-Up Melt
Ins-Hood: Insulated Hood/Reduced Airflow
LMPS: Top Layer of Low Melting Point Soil
Reuse: Reusable Surface Insulation
HTD: High Temperature Dryer to Remove NOx
T-Down: Top Down Method

BG- Bulk Glass
S- Scoria (Top)
Ref- Refractory (Breccia)
Ins- Insulation Board
E- Electrode
B- Metal Box
G- Gas
Start- Materials Prior to Melting
TW- Tank Waste

1 Temperatures X 2 pH Levels = 2 Tests

4 Temperatures X 6 pH Levels = 24 Tests
and
4 Temperatures X 8 Si concentrations = 32 Tests
56 Tests Total

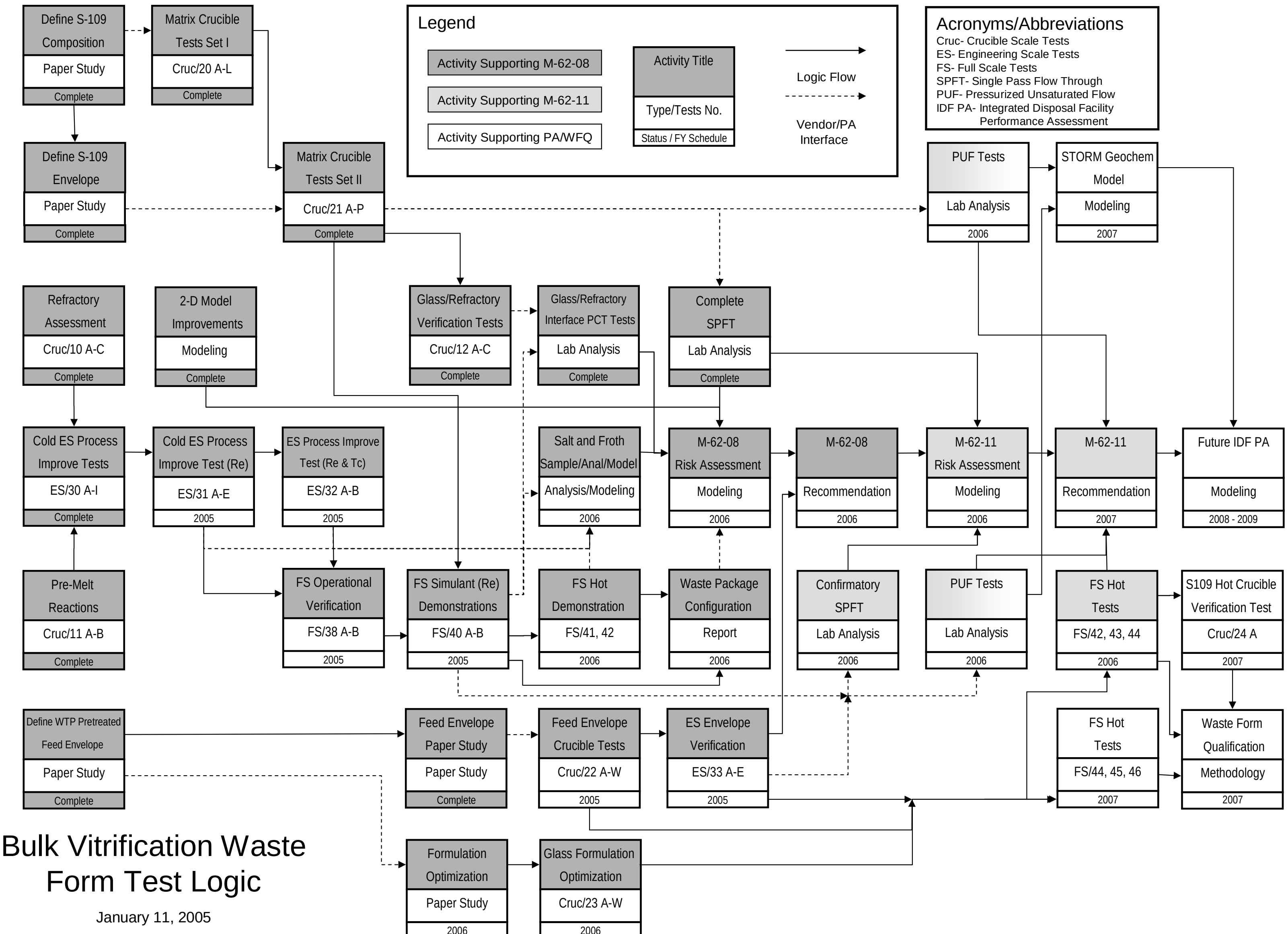
DTA/TGA- Differential Thermal Analysis/Differential Gravimetric Analysis
Gas Anal- Series of off-gas analysis tests
Chem Assay- Series of analyses to determine material composition
Optical Micro- Optical Microscopy
XRD- X Ray Diffraction
SEM/EDS- Scanning Electron Microscopy/Energy Dispersive Spectrometry
TCLP- Toxicity Characteristic Leach Procedure
PCT-A- Standard Product Consistency Test
VHT- Vapor Hydration Test
PCT-B- Modified Product Consistency Tests
Conf SPFT- Confirmatory Single Pass Flow through Test
SPFT-Single Pass Flow through Test
PUF- Pressurized Unsaturated Flow

				Waste Parameters							Analyses																	
			Scale	Waste Loading	Type	Simulant/Tank Waste	Spike	Process Variables	Glass Formers	Sample Location/Type																		
Group Name	Group No.	Test Number	C, E, FS	Wt% Na2O	FY03, S109, S109(+/-), WTP ENV	Sim, TW	Elements	Base, B-Up, Ins-Hood, LMPS, Reuse, HTD, T-Down	Base, Soil(+/-), Add(x), Ref	BG, S, Ref, Ins, E, B, G, Start	DTA/TGA	Gas Anal	Chem Assay	Optical Micro	XRD	SEM/EDS	Porosity	Surface Area	TCLP	PCT-A	VHT	PCT-B	Conf SPFT	SPFT	PUF	Objectives	Milestone	Comments
Refractory Assessment	10	A-C	C	20	FY03	Sim	-	Quenched	Ref 3	Ref	-	-	-	Ref	Ref	Ref	-	-	-	-	-	-	-	-	-	2.A	M-62-08	
Pre-Melt Reactions	11	A-B	C	20	FY03	Sim	-	Quenched	Base	Ref, G	Start	G	-	Ref	Ref	Ref	-	-	-	-	-	-	-	-	-	1.C.i	M-62-08	
Glass/Refractory Verification Tests	12	A-C	C	20	FY03	Sim	-	Slow Cooled	Ref 3	Ref	-	-	-	Ref	Ref	Ref	-	-	-	-	-	Ref, BG	-	-	Ref, BG	2.A	M-62-08	
Matrix Crucible Tests Set 1	20	A-L	C	Varied	S109(+/-)	Sim	-	Quenched and Slow Cooled	Soil (+/-), Add(x), Ref	BG	-	-	-	BG	BG	BG	-	-	BG	BG	BG	-	-	-	-	3.A.i	M-62-08	
Matrix Crucible Tests Set 2	21	A-P	C	Varied	S109(+/-)	Sim	-	Slow Cooled	Base	BG	-	-	-	BG	BG	BG	-	-	BG	BG	BG	BG	-	BG	BG	3.A.i, 3.B	M-62-08	
ES Process Improvement	30	A-I	E	20	FY03	Sim	-	B-Up, Ins-Hood, LMPS, Reuse	Base	BG, S, Ref	-	-	-	Visual Examination of Melts			-	-	-	-	-	-	-	-	-	1.C.i, 2.A	M-62-08	
ES Process Improvement (Re Spike)	31	A-E	E	20	FY03, S109	Sim	Re	Base	Base	BG, S, Ref, G	-	G	BG, S, Ref	BG, S, Ref	BG, S, Ref	BG, S, Ref	S, Ref	S, Ref	BG, S, Ref	BG, S, Ref	BG, S, Ref	-	-	-	-	1.C.i, 2.A, 2.B	M-62-08	Limited Chem Assay for tests C-E
ES Process Improvement (Tc, Re Spike)	32	A-B	E	20	FY03	Sim, TW	Tc, Re, I	Base	Base	BG, S, Ref, G	-	G	BG, S, Ref	BG, S, Ref	BG, S, Ref	BG, S, Ref	S, Ref	S, Ref	BG, S, Ref	BG, S, Ref	BG, S, Ref	-	-	-	-	1.C.i, 2.A, 2.B	M-62-08	Limited Chem Assay for test B
Full Scale Operational Verification	38	A-B	FS	20	TBD	Sim	Re	Base	Base	BG, S, Ref, G	-	-	BG. S. Ref	-	-	-	-	-	BG. S. Ref	-	-	-	BG	-	-	1.C.i. 2.A	M-62-11	Limited WFQ Samples on 38B only
Full Scale Simulant Demonstrations	40	A-B	FS	Base	S109	Sim	I, Re	Base	Base	BG, S, Ref, Ins, E, B, G	-	G	BG, S, Ref, Ins, E, B	BG, S, Ref, Ins, E, B	BG, S, Ref,	BG, S, Ref, Ins, E, B	S, Ref	S, Ref	BG, S, Ref	BG	BG	BG	BG	-	BG, S, Ref	1.C.i, 2.A, 2.B, 3.A.i	M-62-11	
Full Scale Hot Demonstration	41	A	FS	Base	S109	7% TW, 93% Sim	I, Re	Base	Base	BG, S, Ref, Ins, B, G, TW	-	G	BG, S, Ref, Ins, B, TW	BG, S, Ref, Ins, B	BG, S, Ref,	BG, S, Ref, Ins, B	S, Ref	S, Ref	BG, S, Ref	BG	BG	-	-	-	-	1.C.iii, 3.A.ii, 3.C.ii, 2.C, 9.A, 9.B	M-62-11	
Waste Feed Envelope Problem Constituent Identification	22	A-W	C	Base	WTP ENV	Sim	-	Slow Cooled	Base	BG	-	-	-	BG	BG	BG	-	-	BG	BG	BG	-	-	-	-	3.C.i, 3.B	M-62-11	
Glass Formulation Optimization	23	A-W	C	Base +	S-109, WTP ENV	Sim	-	Slow Cooled	Soil (+/-), Add(x)	BG	-	-	-	BG	BG	BG	-	-	BG	BG	BG	-	BG	-	-	3.C.i	M-62-11	
Waste Feed Envelope Verification	33	A-E	E	Base	BOM(+/-)	Sim	I, Re	Slow Cooled	Base	BG, S, Ref	-	-	BG, S, Ref	BG, S, Ref	BG, S, Ref	BG, S, Ref	-	-	BG	BG	BG	BG	BG	-	BG, S, Ref	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 3.C.i	M-62-11	
Full Scale Hot Ramp Up	42	A-E	FS	Base	S109	TW	I, Re	Base	Base	BG, G	-	G	BG, TW	-	-	-	-	-	BG	BG	BG	-	-	-	-	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 9.B, 1.D, 6.A	M-62-11	
Full Scale Hot Baseline Establishment	43	A-E	FS	Base	S109	TW	As Needed	Base	Base	BG, G	-	G	BG, TW	-	-	-	-	-	BG	BG	BG	-	-	-	-	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 9.B, 1.D, 6.A	M-62-11	
Full Scale Hot Process Operational Window	44	A-O	FS	Base	S109	TW	As Needed	Base(+/-)	Soil(+/-)	BG, G	-	G	BG, TW	-	-	-	-	-	BG	BG	BG	-	-	-	-	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 9.B, 1.D, 6.A	M-62-11	
Full Scale Hot Feed Envelope Verification	45	A-O	FS	Base	S109 + Chemical Spikes	TW	As Needed	Base	Soil(+/-)	BG, G	-	G	BG, TW	-	-	-	-	-	BG	BG	BG	-	-	-	-	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 9.B, 1.D, 6.A	M-62-11	
Full Scale Hot Process Improvement	46	A-J	FS	Base +	S109 + Chemical Spikes	TW	As Needed	Base (+/-)	Soil(+/-)	BG, G	-	G	BG, TW	-	-	-	-	-	BG	BG	BG	-	-	-	-	1.C.ii, 2.C, 3.B, 3.C.ii, 9.A, 9.B, 1.D, 6.A	WFQ	
S109 Hot Crucible Verification Test	24	A	C	Base	S109	TW	-	Slow Cooled	Base	BG	-	-	BG	-	-	-	-	-	-	BG	BG	-	-	-	-	3B	WFQ	

Appendix C

Bulk Vitrification Waste Form Test Logic

This appendix is the *Bulk Vitrification Waste Form Test Logic, 2/04/03* that shows how all the tests in the Test Matrix are related.



Bulk Vitrification Waste Form Test Logic

January 11, 2005

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Appendix D

Bulk Vitrification Waste Form Test Purposes

This appendix is the *Bulk Vitrification Waste Form Test Purposes, 3/25/04* that describes the purpose for each group of crucible, engineering scale, and full-scale tests.

Group Name	Group Number	Purpose
Refractory Assessment	10	The purpose of these tests is to screen potential refractory candidates for use in the engineering-scale process improvement tests. Successful refractories would show little penetration of the glass or volatile components into the refractory and would not introduce chemical constituents that would degrade glass waste-form performance.
Pre-Melt Reactions	11	The purpose of these tests is to understand when different pre-melt reactions occur in the waste feed. Examples include determining the amount of moisture lost as a function of temperature, the initial melting point of the salt-waste constituents, the onset of nitrate decomposition, the onset of oxide melting, and level of salt penetration into refractory walls. Understanding these reactions are important to waste-feed system, melter, and offgas system design.
Glass/Refractory Verification Tests	12	The purpose of these tests is to produce samples of the glass/refractory interface for long-term performance assessments. These interface samples are produced by melting the proposed glass formulation in crucibles fabricated from the proposed refractory. These samples will undergo a cooling profile that mimics the temperature profile at the glass refractory interface at key points in the glass package. These tests will help in selecting a refractory that does not reduce overall waste-form performance.
Matrix Crucible Tests Set 1	20	Design glass to account for variations in soil composition, soil/additive to waste ratio, waste composition, and refractory liner incorporation. Determine difference between quenched and slow cooled samples. This test grossly determines the dependence of glass acceptability on the variables tested.
Matrix Crucible Tests Set 2	21	Follow on to first matrix crucible tests. This set of tests uses information from the first matrix and formulates glasses to identify the boundaries between acceptable and unacceptable glass compositions.
ES Process Improvement	30	These engineering-scale tests are used to determine the processing methods that have the highest potential to reduce the presence of soluble Tc salt in the disposal package. Results show that a bottoms up, feed-while-melt methodology with a high plenum temperature generated a glass block that completely reacted all the waste and produced no scoria layer and little or no deposits in the plenum area. Using a castable refractory also minimized penetration and condensation of volatile materials through the refractory wall.

Group Name	Group Number	Purpose
ES Process Improvement (Re Spike)	31	The purpose of these tests is to determine the fate of Re (used as a conservative surrogate for Tc) in an engineering–scale-test vitrification test. Feed materials will be prepared by wetting the waste materials to disperse the Re_2O_7 and then drying the mixture to a temperature that is typical of the baseline design. For 31A and 31B, sampling will include the glass, refractory interfaces, top surfaces, electrodes, smears on the underside of the melt hood, high-efficiency particulate air (HEPA) filters, sand surrounding the refractory, melt bottoms, any other notable areas in the waste form. The glass block will be ground and mixed to generate representative samples of the bulk glass. These analyses will determine the fate of Re and allow for a mass balance. This test will also provide for a confirmation of a design that will be used for subsequent Re+Tc tests. Additional Series 31 tests will be conducted to investigate other possible test configurations and operating conditions. Sampling of these additional tests depends on the purpose of the test.
ES Process Improvement (Tc, Re Spike)	32	The purpose of this test is to determine the fate of Tc in an engineering-scale vitrification test. Re is also added as a spike to verify consistent behavior relative to the Re-only test and to allow a Re/Tc relative volatilization factor to be generated and applied to subsequent full-scale tests spiked with Re. Feed materials will be prepared by wetting the waste materials to disperse the spike materials (Tc_2O_7 and Re_2O_7) and then drying the mixture to a temperature that is typical of the baseline design. Sampling will include the glass, refractory interfaces, top surfaces, electrodes, smears on the underside of the melt hood, HEPA filters, sand surrounding the refractory, melt bottoms, and any other notable areas in the waste form. If necessary, the glass block will be ground and mixed to generate representative samples of the bulk glass. These analyses will determine the fate of Tc and Re and allow for a mass balance. Small amounts of actual tank waste will also be added to one Series 32 test to determine if actual waste behaves differently than the simulant.
Full Scale Operational Verification	38	The purpose of these tests is to verify that the waste-package design can handle the thermal load associated with a bottom-up processing method. These tests also supply early information to determine the scale-up factor associated with extrapolating the results at engineering scale to the full-scale waste package. The Series 38 test are Re spiked simulant tests that will be conducted at the Horn Rapids test site. The tests will be conduced before prototypic drying and off-gas equipment are available and will focus mainly on waste-package performance during melting. The final waste package will also be core drilled using methods planned for production.

Group Name	Group Number	Purpose
Full Scale Simulant Demonstrations	40	The purpose of these tests is to verify that the results obtained in the engineering-scale tests can be scaled to a full-size system using the final RD&D equipment. These tests will also include Re spikes that will validate the Series 38 test results.
Full Scale Hot Demonstration	41	The purpose of this test is to verify that S-109 waste can be processed in a full-size system. This first test will use a significant fraction of S-109 waste (10 to 20%) combined with chemical simulant to mimic the baseline Na loading. This test will help start to validate simulant tests and help determine the fate of Tc in a full-scale melt.
Waste Feed Envelope Problem Constituent Identification	22	The purpose of these crucible studies is to establish boundaries for acceptable glass performance relative to the expected waste envelope. This study will establish any required variations in glass formulation or waste-free modifications (e.g., dilution) necessary to treat the entire waste feed envelope.
Glass Formulation Optimization	23	The purpose of these crucible studies is to determine if glass-formulation changes can reduce life-cycle costs while maintaining all waste-form performance requirements. This study looks at methods to increase waste loading while reducing the dependence on high-cost glass formers.
Waste Feed Envelope Verification	33	These engineering-scale tests are used to verify (when deemed necessary) that variations in waste feed and glass formulations will not result in processing problems that are not apparent at crucible scale. These tests help ensure that full-scale hot tests with S-109 wastes spiked to represent other parts of the feed envelope will produce acceptable waste forms.
Full Scale Hot Ramp Up	42	The purpose of these full-scale hot tests is to evaluate the effect of varying the quantity of S-109 waste used in the waste feed over several melts on waste-form quality. These tests are completed when the waste feed is composed of 100% S-109 waste, and the baseline operating conditions have been established. These tests also support waste-form qualification strategies. Chemical analyses of the inlet waste feed and glass formers along with the process information for each run are combined with final waste-form characterization information to support establishing an acceptable waste-form qualification strategy.
Full Scale Hot Baseline Establishment	43	The purpose of these full-scale hot tests is to establish the variability in the baseline process. While attempting to minimize variations in waste feed, glass-former additions, waste-package configuration, and process variables, several melts will be conducted to determine the amount of waste-form variability that is inherent to the bulk vitrification process. These tests also support waste-form qualification strategies. Chemical analyses of the inlet waste feed and glass formers along with the process information for each run are combined with final waste-form characterization information to support establishing an acceptable waste-form qualification strategy.

Group Name	Group Number	Purpose
Full Scale Hot Process Operational Window	44	The purpose of these full-scale hot tests is to verify the size of a process operating window that will produce an acceptable waste package. While minimizing the variability of the waste stream, the soil glass-former composition, waste-package configuration, and process variables will be varied to verify the effects on the final waste-form package. These processing tests will also include tests to verify that procedures to deal with interrupted melts work as expected. These tests also support waste-form qualification strategies. Chemical analyses of the inlet waste feed and glass formers along with the process information for each run are combined with final waste-form characterization information to support establishing an acceptable waste-form qualification strategy.
Full Scale Hot Feed Envelope Verification	45	The purpose of these full-scale hot tests is to verify that the bulk vitrification process can treat other portions of the waste feed envelope. A varied waste feed will be supplied to the process by adjusting the S-109 chemical composition by adding chemical constituents (e.g., sulfates). Relevant glass-former and processing conditions may also be varied as necessary. These tests also support waste-form qualification strategies. Chemical analyses of the inlet waste feed and glass formers along with the process information for each run are combined with final waste-form characterization information to support establishing an acceptable waste-form qualification strategy.
Full Scale Hot Process Improvement	46	The purpose of these full-scale hot tests is to verify that optimized glass formulations produce acceptable waste forms when processed at full scale with actual waste. These tests also support waste-form qualification strategies. Chemical analyses of the inlet waste feed and glass formers along with the process information for each run are combined with final waste-form characterization information to support establishing an acceptable waste-form qualification strategy.
S109 Hot Crucible Verification Test	24	The purpose of this test is to complete the full test matrix and demonstrate that glasses made with both S109 simulant and tank waste at both crucible and production scales behave in similar manners.

Appendix E

ICV™ Container Diagrams

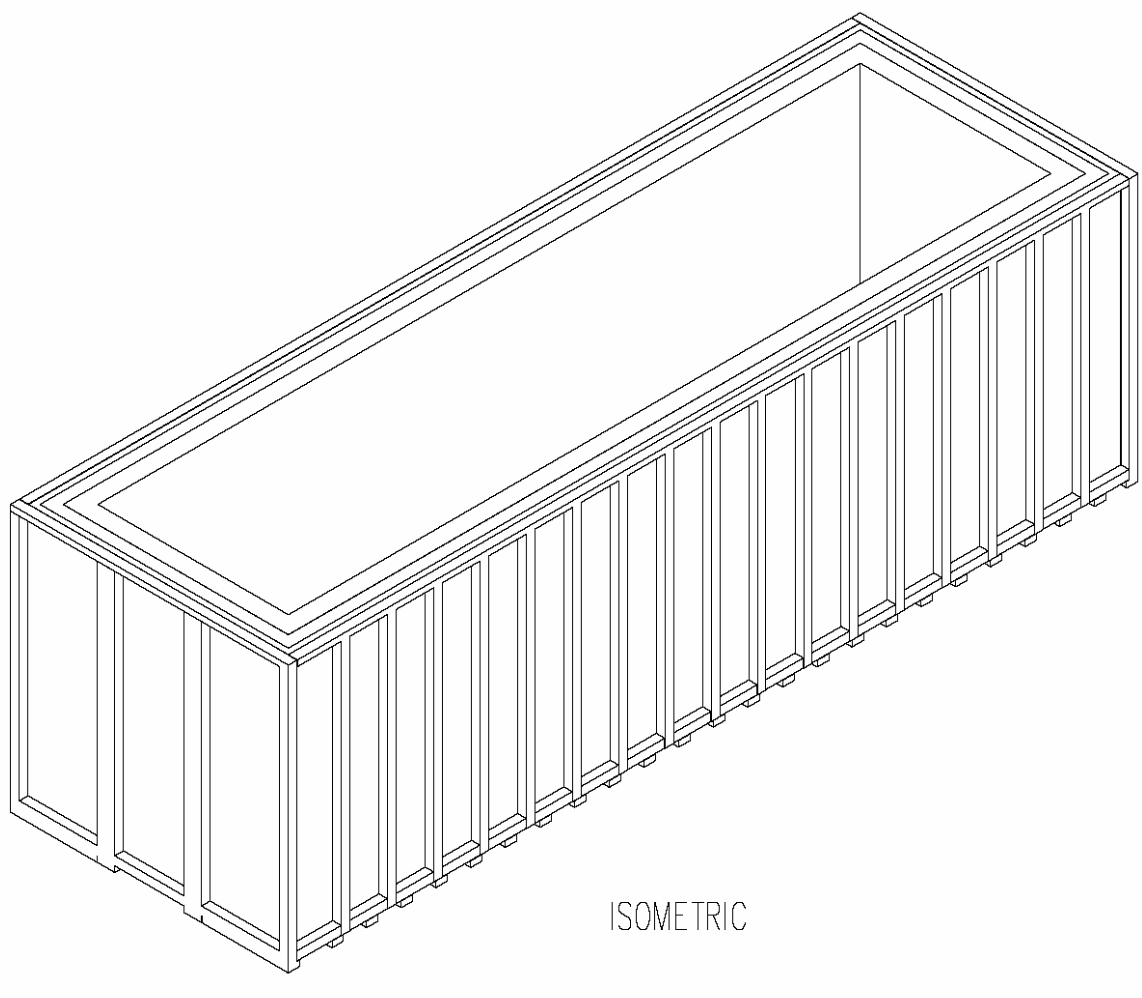

Figure E.1. Isometric Drawing of ICV™ Box with Internal Components(i)

(i) *143643 – Initial DBVS Design Final Report*, RPP-20740 (143643-G-RP-002), DMJM technology and AMEC Earth and Environmental, 2004, Richland, WA.

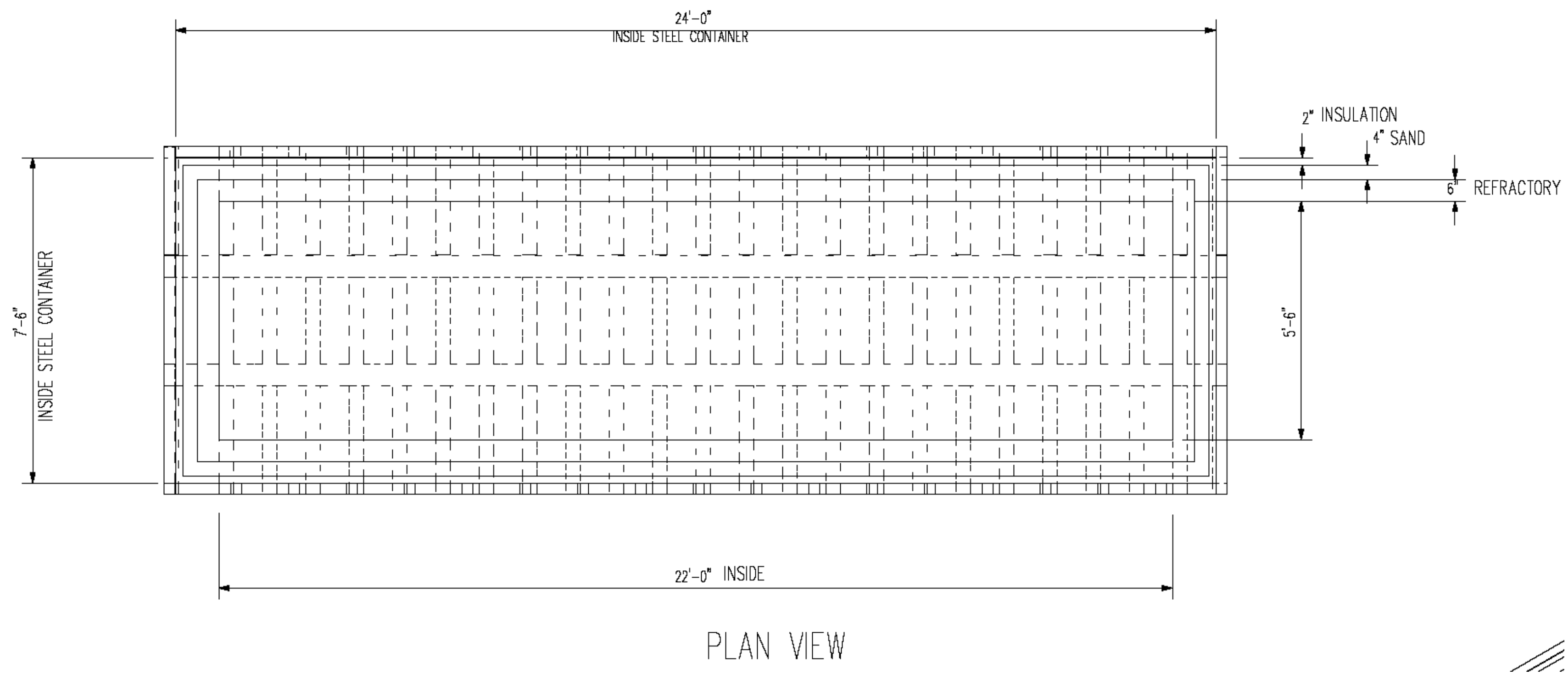

Figure E.2. Plan View of ICV™ Box with Internal Components

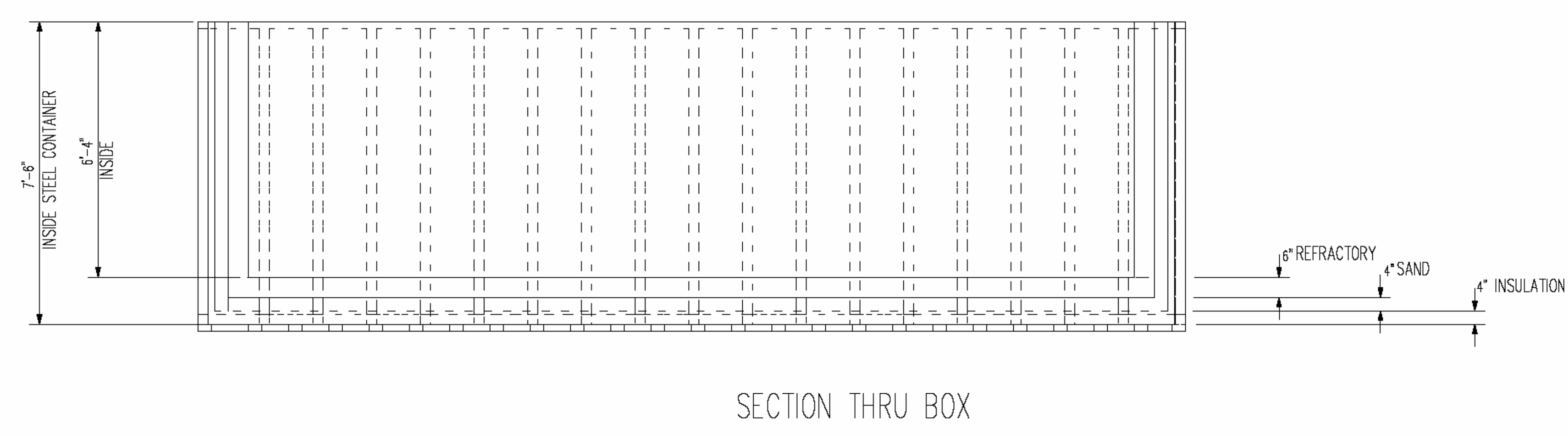

Figure E.3. Cross-Section Drawing of ICV™ Box with Internal Components

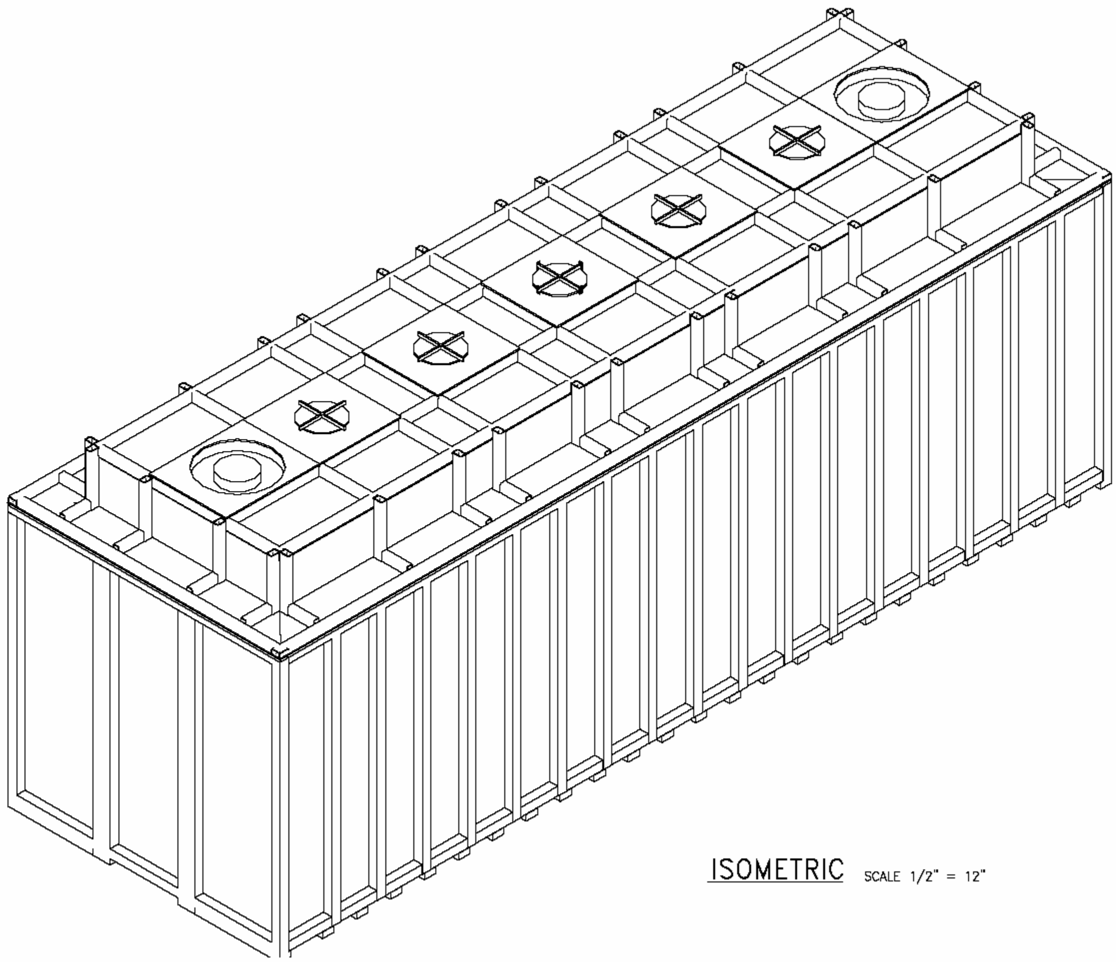

Figure E.4. Isometric Drawing of ICV™ Box with Lid

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