U.S. Department of Energy
Office of River Protection
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

04-WED-088

JAN 03 2005

Mr. J. P. Henschel, Director
Bechtel National, Inc.
2435 Stevens Center
Richland, Washington, 99352

Dear Mr. Henschel:

CONTRACT NO. DE-AC27-01RV14136 – TRANSMITTAL OF U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT ON HIGH LEVEL WASTE (HLW) VITRIFICATION FACILITY TREATMENT CAPACITY, D-04-DESIGN-008

This letter transmits the subject Oversight Report on the Waste Treatment and Immobilization Plant (WTP) HLW Vitrification Facility Treatment Capacity which documents the conclusions and open items that were identified during the conduct of this oversight.

The results of this assessment have determined that the HLW Vitrification Facility supports the WTP Contract design capacity requirement of 6 MTG/d provided that the Pretreatment Facility provides sufficient quantities and concentrations of radioactive waste feed to be used for melter feed make-up. There are no open items identified for the WTP Contractor.

This design oversight did not evaluate the impact of operational availability of the HLW Vitrification Facility. There were no new safety issues identified as a result of this oversight.

If you have any questions, please contact me, or your staff may call William F. Hamel, Jr., Director, WTP Engineering Division, (509) 373-1569.

Sincerely,

for Roy J. Schepens
Manager

WED:WFH

Attachment

cc w/attach:
G. Duncan, BNI
S. Lynch, BNI
J. Schneider, BNI
L. Holton, PNNL

Attachment to
04-WED-088

Waste Treatment Plant
HLW Vitrification Facility Treatment Capacity

D-04-DESIGN-008

December 2004

WED:WFH
December 20, 2004

U.S. Department of Energy, Office of River Protection

Waste Treatment Plant
HLW Vitrification Facility Treatment Capacity

D-04-DESIGN-008

December 2004

Concurrence:

William F. Hamel, Director
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Richland, Washington

Waste Treatment Plant
HLW Vitrification Facility Treatment Capacity

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Executive Summary

Office of River Protection (ORP) staff and technical support contractor staff have conducted a technical Design Oversight of the Waste Treatment and Immobilization Plant (WTP) High Level Waste (HLW) Vitrification facility to evaluate its waste treatment capacity.

The results of this assessment have determined that the HLW Vitrification facility supports the WTP Contract design capacity requirement of 6 MTG/d provided that the Pretreatment facility provides sufficient quantities and concentrations of radioactive waste feed to be used for melter feed make-up. The oversight review also determined that the HLW Vitrification facility is capable of supporting a design capacity of 7.5 MTG/d assuming specific design enhancements:

- A more rapid analysis technique (such as laser ablation) for the characterization and qualification of the HLW melter feed is needed.

- The operation of the HLW melters needs to be evaluated to optimize the operation of the bubblers with respect to bubbler rate, bubbler overlap and bubbler depth. Redesign of the bubblers and HLW melter lid for the second generation melter may be required.

- The expansion of the Glass Former Facility capacity to add a third blend hopper and additional silica storage hopper is required, as also envisioned for the expanded LAW Vitrification facility.

Figure 1 illustrates the magnitude of the design capacities; design margin and capacity enhancements needed for each of the major process and mechanical systems in the HLW Vitrification facility to support a 7.5 MTG/d production rate.

The ability of the HLW Vitrification facility to meet a higher production rate is achieved primarily by taking advantage of design margin resulting from equipment design and operational strategies. At the time of this review the design of the process and mechanical handling systems was ~80% complete. Research and Technology (R&T) testing was also almost complete. Thus, the estimates and evaluations of this oversight reflect a significant degree of certainty.

Several of the mechanical handling systems have design capacities, that have design margins that are significantly greater than minimum requirements. This results from the capability of the mechanical systems that are infrequently used but essential to operations. There are no significant opportunities to reduce capability of these systems in order to reduce capital costs.

Table 2 identifies a number of open items for ORP action to ensure that the design capacity goal of 7.5 MTG/d can be achieved. There are no open items identified for the WTP Contractor.

This design oversight did not evaluate the impact of operational availability of the HLW Vitrification facility.

There were no new safety issues identified as a result of this oversight.

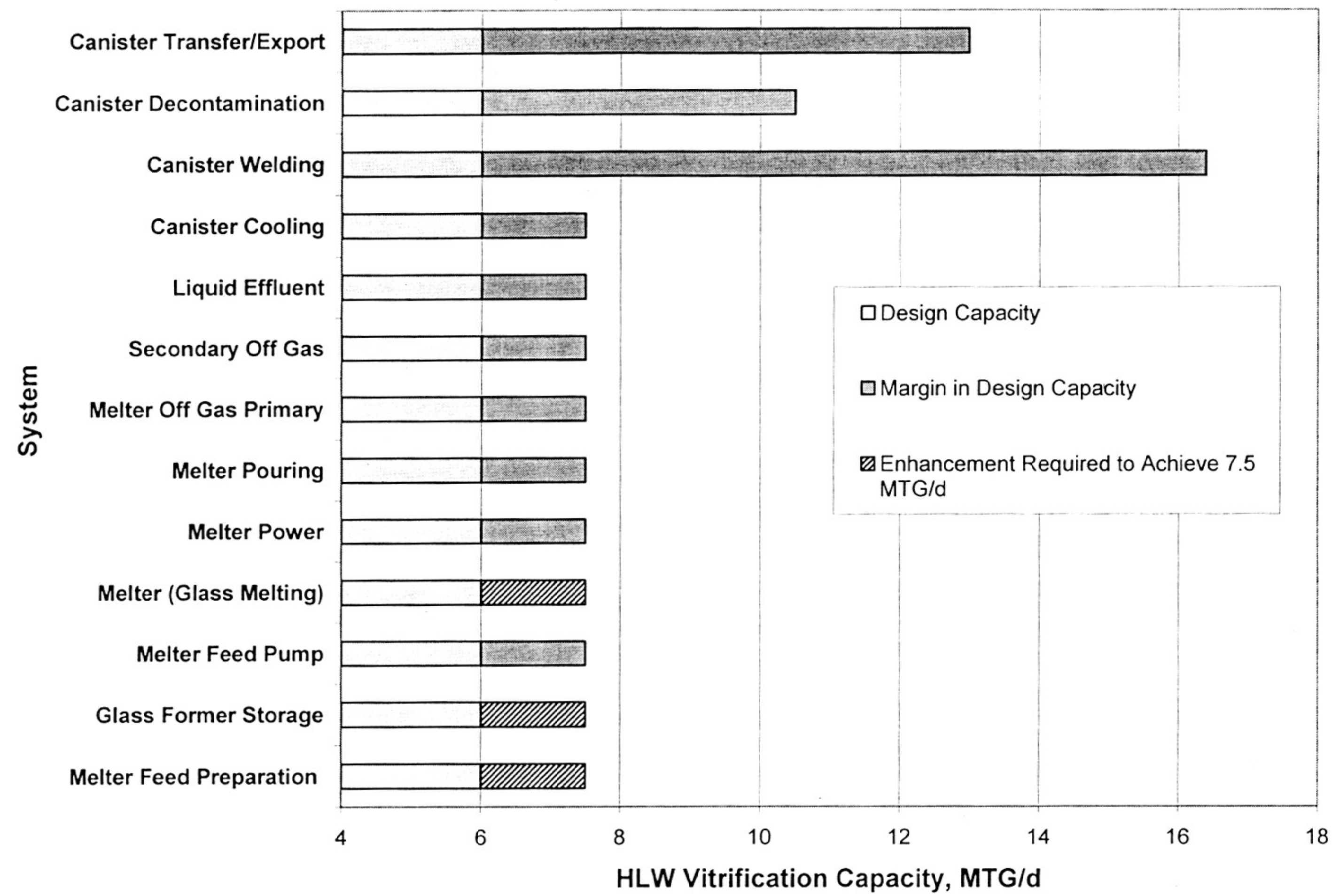

Figure 1 Summary of Design Capacities, Design Margin and Capacity Enhancements Needed for Each of the Major process and Mechanical Systems in the HLW Vitrification Facility to support a 7.5 MTG/d Production Rate

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1.0 Introduction

The Department of Energy, Office of River Protection (ORP) is executing the River Protection Project to retrieve, treat and dispose of the Hanford tank wastes, and environmentally close the waste storage tanks and support facilities. As a principal part of this project, the Waste Treatment and Immobilization Plant (WTP) is currently being designed and constructed to treat and immobilize by vitrification processes the high-level and low-level fractions of the tank wastes. The WTP is comprised of three major facilities: Pretreatment, Low-Activity Waste (LAW) Vitrification and High-Level Waste (HLW) Vitrification. ORP has defined its strategy for treating the waste and closing the tanks in the ORP System Plan (ORP-11242). This strategy assumes that the WTP will be commissioned in 2011 and complete treatment and immobilization of the tank wastes by 2028.

ORP as owner operator of the WTP conducts design oversights to ensure that the WTP will have the capability to meet Contract requirements and to establish what changes or modifications may be required to meet ORP Stretch Goals.

1.1 Objectives

The purpose of this Design Oversight is to determine if the HLW Vitrification Facility systems can support:

- WTP Contract and Basis of Design (24590-WTP-DB-ENG-01-001) requirements for the HLW waste vitrification design capacity, at 6.0 metric ton glass day (MTG/d), and

- A higher HLW vitrification treatment rate of 7.5 MTG/d consistent with ORP's Stretch Case goal.

1.2 Specific Objectives

The following are the specific objectives of this oversight:

1. Determine if the HLW Vitrification facility key process and mechanical systems can support the immobilization of HLW at a design capacity of 6.0 MTG/day as required by the WTP Contract, and WTP Basis of Design (24590-WTP-DB-ENG-01-001). These key process and mechanical systems are:

   - HLW Melter Feed Preparation System (MFPV, MFV, agitators and transfer pumps),
   - HLW Melters (power supplies and melters) ,
   - HLW Melter Off gas Treatment Process (HOP and PVV systems),
   - Canister Processing and Handling Systems (pour cave, canister finishing lines and interim storage including heat removal),
   - Melter Cell and Canister Line Maintenance Systems (viewing, manipulators, cranes and other maintenance equipment and equipment maintenance design features), and
   - Hot cell solid waste management systems (storage, size reduction and packaging of large and small equipment components).

2 Determine if the key process and mechanical systems can support the immobilization of HLW at a design capacity of 7.5 MTG/d (assuming a glass waste loading of 40 wt%). This second case is based upon an internal ORP stretch case treatment goal of 615 HLW canisters/year assuming a 40 wt% loaded glass. The case is termed "8000 in 2025".

1.3 Scope

The scope of this design oversight included the following:

1. Examination of the bases for the design capacity, and margins in the HLW vitrification systems identified above. Identification of the factors that limit design capacity.

2. Evaluate the ability of the HLW feed preparation system to support increased vitrification production rate from the WTP Contract minimum (6 MTG/d or 480 canisters per year) to the ORP stretch goal (7.5 MTG/d or 615 canisters per year at 40 wt% waste loading).

3. Identify enhancements, if required, to achieve ORP's Stretch Case goals.

The Design Oversight was originally scoped to evaluate the basis for the availability of the HLW Vitrification Facility to validate the waste treatment rate[1]. However, this evaluation was not completed because the Reliability, Maintainability and Inspectability (RAMI) evaluations that support establishing the availability are not complete enough to warrant a rigorous oversight. The availability of the HLW Vitrification facility will be evaluated in a subsequent oversight.

1.4 Approach

This design oversight was conducted by collecting and evaluating WTP project documentation and conducting interviews. This information originated from:

- Presentations by key BNI staff on specific lines of inquiry;
- Discussion of the design and construction processes with key BNI staff; and
- Review and evaluation of design documentation.

From November 8, 2004, to December 6, 2004 the Design Oversight the Team met with BNI staff to conduct discussions on each specific objective. A draft of the Design Oversight was provided to BNI for review and comment on December 21, 2004.

[1] The WTP Contract defines waste treatment capacity for each major facility as a product of the facility design capacity (facility nameplate design capacity) multiplied by the overall individual facility availability factor. The Contractor is to establish the facility design capacity through its engineering processes. The Contractor is to establish the facility availability factor from the Operational Research Assessments as defined in Standard 2 (b) (1) Operational Research Assessments of the Waste Treatment and Immobilization Plant.

2.0 Assessment of Design Capacity of the HLW Vitrification Facility

This section presents the results of the design capacity evaluation for the HLW Vitrification facility process and mechanical systems important to waste vitrification design capacity.

2.1 HLW Melter Feed Preparation System

The HLW melter feed preparation system consists of 2 lag storage vessels (HLP-VSL-00027A/B) used to store HLW washed and leached solids and a Blend Vessel (HLW-000028) located in the Pretreatment (PT) facility. These vessels are used to prepare an HLW feed batch for transfer to the HLW Vitrification facility. Feed preparation within the HLW Vitrification facility includes the Melter Feed Preparation Vessels (MFPV) (HFP-VSL-00001 A/B), the Melter Feed Vessels (HFP-VSL-00002 A/B) and two ADS feed pumps for each MFV. Each HLW melter is supported by its own MFPV, MFV and 2 ADS feed transfer pumps. A Glass Former Feed Hopper (GFR-TK-00025) is used to transfer glass forming chemicals to the MFPV and is part of the Glass Formers Reagent (GFR) system.

The design capacity of the HLW Melter Feed Preparation system is influenced by the following:

- Time to prepare and qualify the melter feed including the capability of the glass former addition system, and
- Delivery of feed to the HLW melter.

2.1.1 HLW Feed Preparation Design Capacity

The HLW Feed Preparation (HFP) System is capable of producing sufficient quantities of qualified HLW feed to support HLW Melter operations at a minimum of 350 gram-oxide/liter melter feed, provided that the PT Facility can produce feed with a solids concentration of 17 to 20 wt%, and assuming an average HLW waste loading of 35 wt% using the Glass Properties Model as a method to determine HLW waste loading. The achievement of higher waste loadings (e.g. 40 wt% as assumed in the ORP Stretch Case for this study) will require that the Ultra-Filtration process (UFP) System solids concentration be increased to a minimum of 19 wt% to maintain a melter feed concentration of at least 350 gram-oxide/liter. The ability to operate the UFP System such that washed and leached solids are provided at concentrations greater than ~20 wt% and support a production rate equivalent to 7.5 MTG/d is uncertain based upon the testing data developed to date, and the current issues associated with the design capability of the UFP System (Refer to 04-WED-024).

The design of the UFP System and the requirements to ensure acceptable melter feed concentrations have resulted in a HLW feed preparation system that marginally meets requirements, and may not allow ORP to meet more aggressive treatment goals. The uncertainty in the performance of the process equipment systems places at risk, the ability of the feed system to support effective treatment of the tank waste compositions. The major uncertainties include: the ability of the UFP System to deliver a sufficient concentration, and production rate, of washed and leached solids; and the degree of dilution of the HLW concentrate that will occur due to water additions from transfer line flushing, demister flushing, and GFC dust control.

Open Item 1: ORP should evaluate the results of the studies being conducted by both BNI and the Tank Farm Contractor to resolve the design capacity limitations associated with the WTP Ultra Filtration System, to ensure that the washed HLW solids projected to be produced can support the production of HLW glass at 7.5 MTG/d, using waste loading limits based upon a glass properties model.

The use of Non-Dilute Dissolution (NDD) as an analytical technique to characterize the melter feed appears adequate to support HLW Vitrification facility operations at 6 MTG/d provided that the prepared Melter Feed Preparation Vessel (MFPV) batch size is at least 5000 gallons and the glass yield is at least 350 gram-oxide/liter. A more rapid analytical technique, such as Laser Ablation is needed to characterize the melter feed and support continuous melter operations at 7.5 MTG/d assuming the MFPV batch size is at least 5000 gallons and the glass yield is at least 350 gram-oxide/liter.

Open Item 2: ORP should further evaluate the need for, and, if required, implement a more rapid analytical technique, such as Laser Ablation, to characterize the melter feed to support continuous melter operations at 7.5 MTG/d. This evaluation should be conducted at the time of HLW Vitrification Facility commissioning.

The current BNI sampling and analysis requirements to support the production of HLW glass for the WTP HLW Vitrification facility are two to five times greater than those of the DWPF and former WVDP operations when considered on a unit basis, either MTG produced, or by canister. ORP should evaluate the HLW Product/Process Control strategy following the completion of the BNI contract with the objective of reducing HLW Vitrification facility operations complexity and cost.

Open Item 3: ORP should evaluate the HLW Canister Product/Process control strategy with the objective of reducing the sampling requirements and operational costs to qualify the HLW product.

BNI has not clearly defined the requirements for the HLW concentrate to be produced in the PT facility to be delivered to the HLW Vitrification facility to ensure that the IHLW product will meet the product requirements as defined by the WTP Contract in terms of waste loading, or the requirements defined in the Office of Civilian Radioactive Waste Management in the Waste Acceptance Requirements Document (WASRD). This lack of definition in the interface requirement between Pretreatment and HLW Vitrification continues to place the design of the WTP process systems at risk. The Design Oversight Team recommends that BNI immediately establish an integrated process control definition to guide the design of the WTP process and mechanical systems.

Open Item 4: ORP should continue to monitor the progress and adequacy of BNI efforts to establish the HLW Feed Process-ability Specification as required for the HLW Product/Process Control Strategy.

2.1.2 Glass Former Addition System

The Glass Former Reagent (GFR) system will be adequately sized to support the expanded HLW Vitrification capacity of 7.5 MTG/d design capacity (assumes production capacity of 5.2 MTG/d), following the expansion of the capacity to support LAW Vitrification at 45 MTG/d. The expansion of the GFR system to add a third blend hopper and additional silica storage hopper is not part of the current procurement specification. However, the provisions to add this capability at a latter date are included in the design concept.

2.1.3 ADS Pump Design Capacity

The ADS pump system is capable of supporting a melter feed rate equivalent to a maximum of >6 MTG/d for each melter, assuming a glass yield of 400 gram oxide/liter and an operating stroke frequency of 30 seconds. The operating lifetime of the ADS pump decreases with decreasing operating stroke frequency. The ADS Pump design will not limit the HLW glass production rate in the production range of 3.75 MTG/d/melter.

2.2 HLW Melter Systems

The design capacity of the HLW Melter System is influenced by the following:

- Melter electrode power, and
- Melter bubbler dynamics

The melter glass production rate is also impacted by the glass yield of the melter feed.

2.2.1 HLW Melter Electrode Power

The electrode power requirements for the WTP melter were estimated based upon heat loss calculations and are specified to be in the range 520 to 600 KW. This electrode power level will support the production of HLW glass at a rate of 2.7 to 3.5 MTG/day assuming an HLW glass yield of 350 to 400 gram oxide/liter. The power system has a design margin and can accommodate increased power levels up to an estimated 675 KW. This increased power level can support glass production at a rate of 3.9 to 4.2 MTG/day assuming an HLW glass yield of 350 to 400 gram oxide/liter, respectively. There are no obvious limitations in the electrical power distribution system (electrodes, electrode buss bars and electrical conduit between the power transformer and the electrode buss bar). The current conservatism in the melter power system design will be increased at higher waste loadings resulting in a higher glass production rate because less energy is needed to melt a fixed mass of glass.

2.2.2 Melter Bubbler Operation

The efficiency of operation of the HLW melter bubblers is critical to achieving the design capacity of the HLW melter. Sufficient testing was completed on the non radioactive DM-1200 test melter, combined with a reasonable approach to extrapolate the testing data for the WTP melter, to justify an early determination that the WTP melter capacity will achieve a glass melting rate of 3 MTG/d. This glass production rate assumes that the WTP melter has a glass surface area of 3.75 m^2 and a required glass production rate of 800 $kg/m^2/d$.

Based upon the design of the WTP melter, and analysis completed on the impact of bubbling on glass production rates (24590-101-TSA-W000-0009-162-00001), it is possible to substantially increase the melting rate of the HLW melter. Technical changes to the bubbler operations which were not completely evaluated in the DM-1200 melter testing because of design limitations include: bubbler depth, bubble rate and bubbler overlap. Each of these factors can independently be used to increase the glass production rate. Based upon the analysis completed in 24590-101-TSA-W000-0009-162-00001 it should be possible to increase the production of the WTP melter to 3.75 MTG/d. However, redesign of the melter lid may be required to increase the number and location of additional bubbler assemblies.

Based upon testing completed in the DM-1200 melter there appears to be a process trade-off between the bubbler melt rate and solids (glass and feed) entrainment into the melter film cooler and off-gas system. This may require that the film cooler be mechanically cleaned. During a number of the bubbler tests in the DM-1200, the film cooler was partially plugged with glass particulate made mobile by the bubbling of the glass pool. In these experiments the film cooler needed to be cleaned to remove blockage with a rod. Attempts to flush the film cooler were unsuccessful. Cleaning with a rod occurred as much a twice per day. The potential for blockage of the film cooler represents a risk to HLW vitrification plant production testing.

A prototype of the melter film cooler cleaner was designed for the WTP melter (24590-101-TSA-W000-0010). However the film cooler cleaner was not tested to validate the design concept. BNI plans on testing the film cooler cleaner during the commissioning phase of the HLW Vitrification facility.

> *Open Item 5: ORP should monitor and evaluate the WTP melter/film cooler test results obtained during cold and hot commissioning to ensure that the melter design provided is capable long term maintenance free operation.*

2.2.3 Melter glass pour rate

The HLW melter is designed with two pouring chambers, each of which fills a separate canister located on a separate bogie track system. Melter glass discharge rates in the range of 200 to 500 kg/h are needed to allow the glass stream to fall approximately 20 feet to the bottom of an empty canister in the initial canister pour and allow the glass to flow to the periphery of the canister. At 3 MTG/d the average pour rate is 125 kg/hr and at 3.75 MTG/d the average pour rate is 156kg/hr. The change in melter glass level should be limited to less than 1 inch to minimize thermal shock to the glass contact refractory at the slurry to glass melt line. One inch of glass is equivalent to about 230 kg of glass. Based upon this design basis pour parameters are summarized below. The increase in glass production capability will require that the WTP melter decrease the time duration between pours from 1.8 to 1.5 hours.

The glass pouring operation in the HLW melter does not limit the production capacity of the HLW melter in the range 3 to 4 MTG/d.

Glass Discharge Parameter	3 MTG/d Melter	3.75 MTG/d Melter
Glass Production Rate, kg/d	3000	3750
Glass Discharge Rate Maximum 500 kg/hr	500	500
Mass of Glass/Discharge, kg	230	230
Number of Glass Discharges/canister	13.5	13.5
Discharge Time, hr	0.5	0.5
Melter Recovery Time, hr	1.8	1.5

2.2.4 Expected HLW Melter Design Capacity

The current design of the WTP melter appears adequate to support a WTP Basis of Design rate of 3 MTG/d per melter based upon the following factors:

- Melter power system design
- Bubblers impact on glass production capability
- Feed quality to be delivered to the HLW melter

2.2.5 Improvements in Melter Production Rate

There are a number of potential improvements to the design and operation of the melter feed preparation system than can be made to increase the design capacity of the WTP HLW melter to achieve a production capacity of 3.75 MTG/d. These process and design improvements include:

1. Increasing the power level to the melter electrodes.
2. Increasing the glass operating temperature.
3. Optimize Melter Bubbler Design/Operations-Deeper Bubblers.
4. Optimize Melter Bubbler Design/Operations-Increase Bubbler Air Flow Rate.
5. Optimize Melter Bubbler Design/Operations-Increase Bubblers Overlap/Bubbler Area.
6. Increasing the glass yield of the HLW Melter Feed.
7. Increase Melter Surface Area.

Each of the potential methods, including its basis for consideration, potential glass production rate improvement, major issues, and probability of success was evaluated. This assessment indicates that the first four of these can be accomplished with no modification to the existing design of the HLW melter system. Redesign of the melter lid is required for Item 5. The last item results in a greater design impact and should only be considered if the other approaches are determined to be unsuccessful. Based upon existing technical information, there is a high probability that a combination of the first five approaches can be used to increase the HLW melter production rate.

Open Item 6: ORP should evaluate the production capability of the WTP melter during the cold and hot commissioning phases of the BNI Contract. Based upon these test results, additional R&T Testing of the bubbler design and layout, and design modifications to the second HLW melter to improve production capacity to 3.75MTG/d should be identified.

2.3 Off-gas Treatment System

The processing vessels and melters, within the HLW Vitrification facility, generate gaseous waste offgas streams that must be treated to clean these respective offgas systems to constituent levels acceptable for release into the environment. In the BNI WTP design, for the vitrification of high-level waste, the melter off-gas treatment system is designated as the HOP system and the process vessel vent (PVV) system. The offgas from both of these systems are brought together at an intermediate processing point within the processing (HOP) system for the melter offgas. Process condensates and recycle from the HOP and other HLW Vitrification facility systems are collected in the radioactive liquid waste system (RLD) before transfer back to the PT facility for additional treatment.

The Oversight has determined that the Melter Offgas System (HOP and PVV) and RLD System have sufficient design capacity to support the operation of the HLW Vitrification System at the WTP Basis of Design requirement of 3 MTG/d/melter line, and at an Enhanced Capacity of 3.75 MTG/d/melter. The impacts to the process systems are modest due to the increased design treatment capacity. The liquid waste from enhanced the HLW melter operations will increase by about 25% which will increase the frequency for transfer of condensates from the HLW Vitrification facility to the Pretreatment facility from once every day to once every 18 hours.

2.4 Canister Processing and Handling Systems

Figure 1 shows schematically the path of the IHLW canisters into, through and out of the HLW facility. This figure shows the canister processing and handling activities for the following systems:

<u>HRH – Canister Receipt Handling</u> provides the mechanical equipment, controls and instrumentation required for importing HLW Canisters into the HLW facility. The functions of this system include receipt and staging an empty canister, inspecting the canister and transfer through the Canister Import Room and Import Tunnel for transfer to the Canister Handling Cave.

This is a clean, low radiation system so maintenance and repair activities are performed within the rooms. A Bogie maintenance bench is provided in the import tunnel for that purpose.

<u>HPH – Canister Pour Handling System</u> transports the empty product canisters and full IHLW canisters within the HPH system facilities, supports canister filling and performs canister sampling, lid closure and rework, if required. The system operates in two areas:

- The Canister Handling Cave
- Pour tunnels for melters 1 and 2

The weld station has two positions which can be used for measuring the temperature of the canister flange, measuring the level of glass in the canister, taking glass shard samples and transporting them out of the cave for analysis and welding on the lid.

The canister cooling racks store the filled canisters while they cool prior to welding on the canister lid. The canister buffer rack temporarily stores empty canisters or full canisters that have cooled sufficiently to be welded.

Maintenance of the major equipment, (e.g., the cranes and bogies) is performed "hands-on" in the dedicated maintenance areas after decontamination.

HDH—Canister Decontamination System removes smearable radioactive contamination from the filled and sealed canister surface to meet the IHLW requirements.
The system includes two areas:

- Canister Swab and Monitor Cave
- Canister Storage Transfer Tunnel

All maintenance of the cranes and bogies is performed "hands-on" in dedicated facilities after decontamination.

HEH – Canister Export Handling System receives "clean" canisters from HDH, racks them in temporary storage, prepares canisters for shipment, imports a clean shipping cask, loads a canister into the cask and exports that cask out of the facility for shipment to the Canister Storage Building.

The system includes the following areas:

- Canister Storage Area
- Canister Export Tunnel
- Loading Area
- Truck Bay

All of the equipment is to be maintained "hands-on" after any required decontamination.

The design capacity of the HLW canister processing and handling system is influenced by the following:

- Heat removal in the canister pour cave and finishing line.
- Interim storage of HLW canisters.
- Time cycle for canisters batch processing.

2.4.1 Heat removal capacity for pour cave and finishing line

Design analyses performed for bounding canister and system conditions at a glass production rate of 3MTG/day per melter confirm that the HLW C5 system is capable of maintaining area, air leaving and structure temperatures within required ranges.

The effect of increasing the glass production rate by 25 % would be to increase the most limiting heat load in the pour cave tunnels by ~15% to 17 %. This is within the conservatism of the heat transfer analyses and the design margins in the system for area and air leaving temperatures. Although it is judged that structural temperatures will also be acceptable during pouring, additional CFD analyses or actual measurements would be required to confirm that the potentially higher canister temperatures that may be reached during pouring do not result in excessive structural temperatures.

Open Issue 7: Following hot commissioning ORP should require the WTP Operations Contractor to update the heat load and temperature estimates based on actual operating conditions and establish if any adjustments in HVAC in the pour cave or finishing line would be required to increase the glass production rate to 3.75 MTG/day per melter.

2.4.2 Interim Storage of HLW canisters; Canister Cooling Rate for Production and Canister Ship-out Requirements

The canister processing and handling line includes sufficient provisions to store canisters during cooling and processing to support the WTP Contract production rate of 6 MTG/d and the ORP Stretch Goal of 7.5 MTG/d. These include the Cooling Racks and Buffer Rack in the Canister Handling Cave and the Storage Rack in the Export Cave.

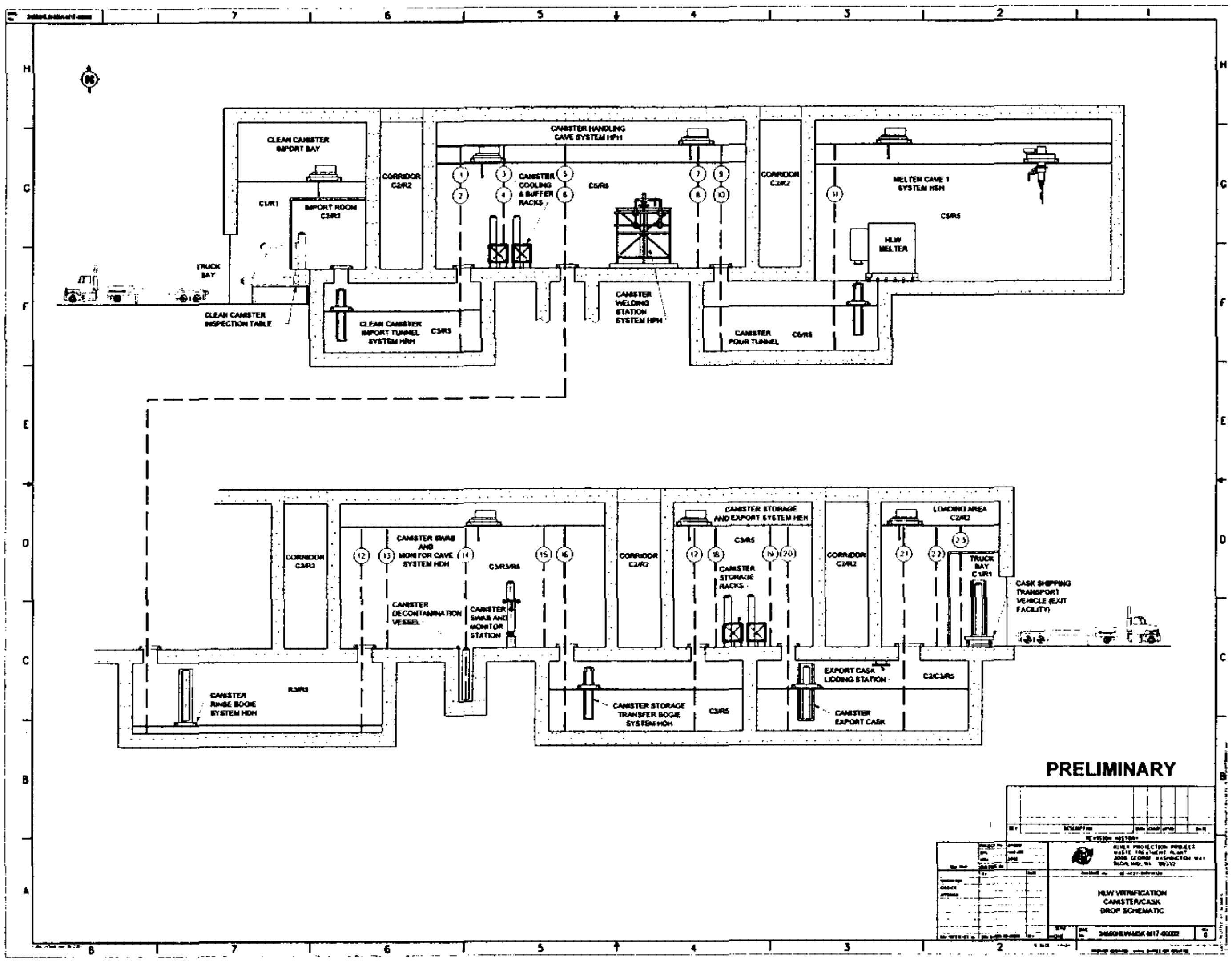

Figure 2 Canister Handling Schematic

2.4.3 Time cycle for canisters batch processing

The Operations Research (Witness) Model developed, operated and maintained by Central Engineering/Process Operations is used to confirm the functionality of the WTP systems including those conducting HLW canister batch processing. The model runs to-date indicate that the systems will support a peak production rate of 3 MTG/day/melter and, after considering RAMI data for the equipment, a net production rate of 415 Canisters per year with a ~15% margin (Operational Research Assessment Report 24590-WTP-RPT-PO-03-045, Rev 0). An assessment of the specific mechanical handling equipment indicates that the most limiting area is the decontamination station. Based on the current estimated timeline this station could support a peak throughput of 3.4 canisters per day (10.5 MTG/d). Accordingly, a utilization factor of ~70% would be required to support the ORP Stretch Goal of 7.5 MTG/d peak production.

A brief review of the Operational Research Model resulted in the following observations and conclusions:

- Neither BNI Systems Engineering nor BNI Design Engineering have completed reviews of the model input data or its configuration. Considering the critical role of this model in confirming the functionality of the plant, Systems and Design Engineering should have a more active role in confirming the veracity of the modeling.

- It is not clear how Human Factors are considered in the assessment of the Mechanical Handling System timelines. Human factors should be considered in assessing the functional capabilities of systems in which operator actions are required to complete system functions.

- The model does not appear to include the buffer rack in the Canister Handling Cave. It should be determined if the model includes the Canister Buffer Rack and, if it does not, provide justification for not including this rack in the model.

- This model is a valuable tool for confirming the functionality of plant systems and identifying potential pinch points in plant throughput. This model should be kept up-to-date through plant cold and hot commissioning and be turned over to the operating contractor for use as a training and design modification tool during plant operation.

  Open Item 8: ORP should conduct an additional detailed design oversight on the Operational Research Model used to estimate plant availability to further evaluate the issues identified in the HLW Vitrification facility design oversight. The scope of this oversight should include all major WTP facilities.

2.4.4 Redundancy and robustness in canister handling systems

Redundant components have been provided in the welding station and the decontamination station to obtain acceptable utilization rates at Contract peak production rates. The decontamination station limits the throughput of the canister handling line. Rough order of magnitude assessments indicate that this station could support a peak production rate of 3.4

canisters per day (10.5 MTG/d); requiring 60% utilization to meet Contract requirements of 2 canisters per day (6 MTG/d) and 70% utilization to meet ORP Stretch Goal peak production rate of 7.5 MTG/d.

2.4.5 Single Point Failures in the Canister Pouring through Finishing Line

Single point failure vulnerabilities in the canister handling systems include most of the cranes, bogies and the swabbing turntable. These are not judged to be limiting with respect to canister line production since these components have very low utilization rates, their Mean Times Before Failure (MTBF) are long compared to their required operating times and the limiting process cycle times, (e.g., melter pour times and canister decontamination), and the Mean Times to Repair (MTTR) are short compared to the process cycle times.

2.5 Melter Cell and Canister Line Maintenance Systems

The maintenance capabilities of the Melter Cell and Canister Processing Lines are important in establishing the overall capacity and availability of the HLW Vitrification facility. The Oversight evaluated the areas of:

- Viewing of In-Cell Operations and Maintenance Activities.
- Remote Maintenance Requirements.
- Service Duty of Remote Maintenance Equipment
- Facility Capability to Replace Process Equipment
- Identification/Design of special tools for maintenance

2.5.1 Operator viewing requirements and basis (e.g., direct, remote)

The operator viewing provisions are based on providing direct viewing (leaded glass windows) at locations where the operator performs "hands-on" functions. Additionally, in-cave and out-of-cave Close Circuit Television (CCTV) cameras are used to provide remote viewing of all operations conducted in the HLW facility including operations that use direct viewing. This philosophy and approach are judged to be appropriate to establish where direct and/or remote viewing is provided for operator functions.

The scope of this oversight did not include an assessment of the full scope of viewing provisions. Based on the sample reviewed (principally in the melter cave and the pour tunnel) the philosophy was effectively implemented.

2.5.2 Identification of remote maintenance requirements and their basis (e.g., MSM, PAR, crane)

The HLW facility has been designed and equipment has been specified to perform hands-on maintenance of major in-cave support equipment, (e.g., cranes, bogies, PARs, MSMs, cameras). This is accomplished by providing dedicated facility space to support decontamination and repair for this equipment. The maintenance requirements are specified by the equipment supplier as required to meet the functional requirements and lifetime of the equipment specifications.

In-cave maintenance/replacement of melters, filters, etc. is performed using in-cave cranes, MSMs, and powered manipulators principally to replace consumables, (e.g., bubblers, filter elements). The Wet Electrostatic Precipitator (WESP) is also designed for remote replacement of the electrodes. These components are designed to facilitate the remote replacement operations.

2.5.3 Expected Service Duty of remote maintenance equipment and basis (e.g., preventative maintenance, unanticipated repairs)

As noted in the preceding discussion, other than replacement of consumables, (e.g., in the melter, filters, WESP) in-cave equipment maintenance will be performed hands-on in dedicated shielded facilities after decontamination of the equipment. This includes cranes, manipulators, motors, pumps, agitators, bogies, hatches. Small equipment such as nut runners, impact wrenches, saws, shears, etc. will be replaced rather than maintained. Accordingly, this is not considered a vulnerability to facility throughput.

2.5.4 Facility Capability to Replace Process Equipment

The equipment located in the Melter Cell and canister handling lines are capable of being remotely replaced. Provisions are provided to replace, for example, the Melter Feed Preparation Vessel, the Melter Feed Vessel, the HEME vessels, if required, using the used melter transport cask and special racks designed for that purpose. (24590-HLW-3YD-HSH- {TBD}, System Description for High Level Waste Vitrification Facility Melter Support System, to be prepared in early 2005). Process equipment that cannot be replaced include the:

- WESP Vessels(HOP-WESP-00001/00002)
- SBS Condensate Receipt Vessels (HOP-VSL-00903/00904)
- Acidic Storage Vessel (RLD-VSL-00007)
- Plant Wash and Drains Vessel (RLD-VSL-00008)

2.5.5 Identification/Design of special tools for maintenance

There are few special tools that have identified for remote maintenance of equipment. Major equipment and maintenance and repair or replacement is performed hands-on in dedicated shielded facilities. Special features are provided on decontamination water spray and CO_2 spray wands to facilitate remote handling. Where in-cave replacement of consumables or recovery of failed equipment is required special features are provided in the design of the affected equipment to facilitate these actions.

2.6 Hot Cell Solids Waste Management Systems

2.6.1 Identification of Solid Waste Types and Quantity

The projections of solids waste type and volume for the HLW Vitrification Facility are preliminary. The major source of waste from the facility will be:

- HEPA filters packages as low-level waste in 55 gallon drums
- Melter cave consumables contaminated with glass (e.g bubbler assemblies, dip legs) and packaged as TRU waste in 55 gallon drums.
- Melter cave consumables not contaminated with glass (e.g bubbler assemblies, dip legs) and packaged as low-level waste in 55 gallon drums.
- Large equipment components (e.g. spent melters, and potentially vessels) infrequently removed in the HMH system.

2.6.2 Capability for temporary storage of solid waste

There is adequate temporary storage provided for solid waste that is likely to be generated during normal plant operation. This includes permanent waste bins and the waste baskets that are filled to transport the waste out of the caves as well as lay down space on false flooring and grates for larger components that require re-sizing prior to packaging for disposal.

2.6.3 Time dependency for solid waste ship out

It is judged that the radioactive sold waste system is adequate to receive and dispose of solid waste generated in the facility without impacting glass production rate.

2.6.4 Approach and capability for size reduction

Sufficient means are provided to perform necessary size reductions of components and equipment that will or may require replacement during normal plant operation.

2.6.5 Strategy for removal/packaging of large failed equipment from melter cell and canister finishing line

Sufficient means are provided for removal and packaging of large failed equipment from the melter cell, e.g., feed preparation and feed vessels, HEME vessels, and the canister finishing line, e.g., cranes, bogies.

3.0 Estimate of HLW Vitrification Facility Capability

The information collected and developed as part of the design oversight can be used to estimate the design capability of the HLW Vitrification facility. This information is summarized in Table 1 below and in Figure 3.

The results of this assessment have determined that the HLW Vitrification facility will support the WTP Contract design capacity requirement of 6 MTG/d provided that the Pretreatment facility can provide sufficient quantities and concentrations of radioactive waste feed to be used for melter feed make-up. In addition, the oversight determined that the HLW Vitrification facility is capable of supporting a design capacity of 7.5 MTG/d assuming specific design enhancements are completed. These are:

- A more rapid analysis technique (such as laser ablation) for the characterization and qualification of the HLW melter feed is needed.
- The operation of the HLW melters needs to be evaluated to optimize the operation of the bubblers with respect to bubbler rate, bubbler overlap and potentially bubbler depth. Potential redesign of the bubblers and HLW melter lid for the second generation melter to optimize bubbler number and layout may be required.
- The expansion of the Glass Former Facility capacity to add a third blend hopper and additional silica storage hopper as envisioned for the expanded LAW Vitrification facility expansion is required.

Figure 3.1 illustrates the magnitude of the design capacities; design margin and capacity enhancements needed for each of the major process and mechanical systems in the HLW Vitrification facility to support a 7.5 MTG/d production rate.

The ability of the HLW Vitrification facility to meet a higher production rate is achieved primarily by taking advantage of design margin that exists as a result of equipment component design and current operational strategies. At the time of this review the design of the process and mechanical handling systems for the HLW Vitrification facility was ~80% complete. Research and Technology (R&T) testing was also almost complete. Thus, the estimates and evaluations that have been made in this oversight reflect a significant degree of certainty.

Several of the mechanical handling systems (Canister Import/Export, Canister Decontamination and Canister Welding) have design capacities, which when considering design margins, are significantly greater than minimum requirements. This is primarily a result of the capability of mechanical systems which are infrequently used but essential to plant operations. There are no significant opportunities to reduce capability of these mechanical systems to reduce capital cost of the HLW vitrification facility.

Table 1 Summary of Design Capacities, Design Margin and Capacity Enhancements Needed for Each of the Major Process and Mechanical Systems in the HLW Vitrification Facility to support a 7.5 MTG/d Production Rate

Process/ Equipment System	Design Capacity. MTG/d	Margin, MTG/d	Capacity Enhancement Needed, MTG/d	Comments
Melter Feed Preparation	6	0	1.5	The capacity of the melter feed preparation system is limited by an assumed minimum HLW melter feed glass yield of 325 gram oxide glass/liter and use of Non-Dilute Dissolution as the analytical technique used to qualify the HLW melter feed. The process system can support a higher production rate if a more rapid analytical technique such as laser ablation is used for melter feed qualification. Laser ablation is not a reference analytical technique that will be qualified in the WTP project. The HLW solids concentration from the pretreatment facility needs to be at least ~19 to 20wt% to achieve the expanded capacity treatment objectives.
Glass Former Storage	6	0	1.5	The Glass Former Storage System has sufficient design capacity (with the addition of the Silica hopper and Blend Hopper) used to upscale its capacity to support the expanded LAW Vitrification facility at 45 MTG/d and the HLW Vitrification Facility.
Melter Feed Pump	6	1.5	0	The ADS melter feed pump has sufficient design capacity to support the expanded treatment rate of the HLW melter. The ADS pump stoke frequency can be shortened to increase the pump rate to the required production level.
Melter	6	0	1.5	The operation of the HLW melter bubbler system has not been optimized to improve melter capacity. Improvements in the performance of the bubblers by: 1) increased depth of operation as will occur in the WTP melter compared to the test melter, 2) increased bubble rate and 3) increased bubbler overlap can increase the production rate of the HLW melter. These improvements may require a redesign of the melter lid and some testing on bubble dynamics in a test chamber. The cold commissioning and hot commissioning phases of WTP melter operations will provide more information on the extent of enhancements required to achieve the glass production rate.
Melter Power	6	1.5	0	The melter power system has sufficient design capacity to support the expanded treatment rate of the HLW melter. The melter electrode power system has sufficient design margin to support increase melting power requirements. However if the bubbler operation is optimized that additional power requirement may not be necessary.
Melter Pouring	6	1.5	0	The melter pouring system has sufficient design capacity to support the expanded treatment rate of the HLW melter at 7.5 MTG/d. The pouring capacity is of each of two pour chambers on each melter is 12 MTG/d (500 kg/hr). The duration between glass pours can be shortened to increase the planned average pour rate of each mleter (3 MTG/d) to 3.75 MTG/d.

Process/ Equipment System	Design Capacity. MTG/d	Margin, MTG/d	Capacity Enhancement Needed, MTG/d	Comments
Melter Off Gas Primary	6	1.5	0	The Primary melter off gas system (HOP System) has sufficient design capacity to support the expanded treatment rate of the HLW melter. The increased waste feed flow rate will increase the condensable (steam) off gas flow rate between the melter and submerged bed scrubber. This off gas stream is ~10% of the total flow. The submerged bed scrubber has sufficient heat removal capacity (about 100% margin in normal operations) to handle a 25% increase in melter feed rate.
Secondary Off Gas	6	1.5	0	The Secondary Off-gas system has sufficient design capacity to support the expanded treatment rate of the HLW melter. The increased flowrate from non-condensable off gas is not expected to significantly change as a result of the increase in melter feed rate.
Liquid Effluent	6	1.5	0	The Radioactive Liquid Waste system has sufficient design capacity to support the expanded treatment rate of the HLW melter. The transfer rate of liquid effluents from the HLW Vitrification facility to the Pretreatment facility will need to increase from one/day to about once every 18 hours.
Canister Cooling	6	1.5	0	The built in design margins and conservatisms in heat load assumptions for the cooling of the HLW canister in the pouring tunnel and the cooling racks provide at least 15% to 17% margin in cooling capacity that is required to accommodate a 25% increase in production rate.
Canister Welding	6	10.40	0	The canister welding operations have a current available time of 9.1 hours for glass sampling and welding (including transport) and also have the provision for two welding stations. This margin allows for the welding of up to 5.3 canisters/day or 16.4 MTG/d.
Canister Decontamination	6	4.50	0	The cerium decontamination station assumed a current time of 14.2 hours for decontamination, including transport. With a design concept having two decontamination stations the system is capable of 10.5 MTG/d or 3.4 canisters/day.
Canister Transfer/Export	6	7.00	0	The built in design margins and conservatisms in heat load assumptions provide at least 15% to 17% margin in cooling times (e.g. rate at which canisters can be moved through the canister handling steps) allow for a 25% increase in canister production rate.

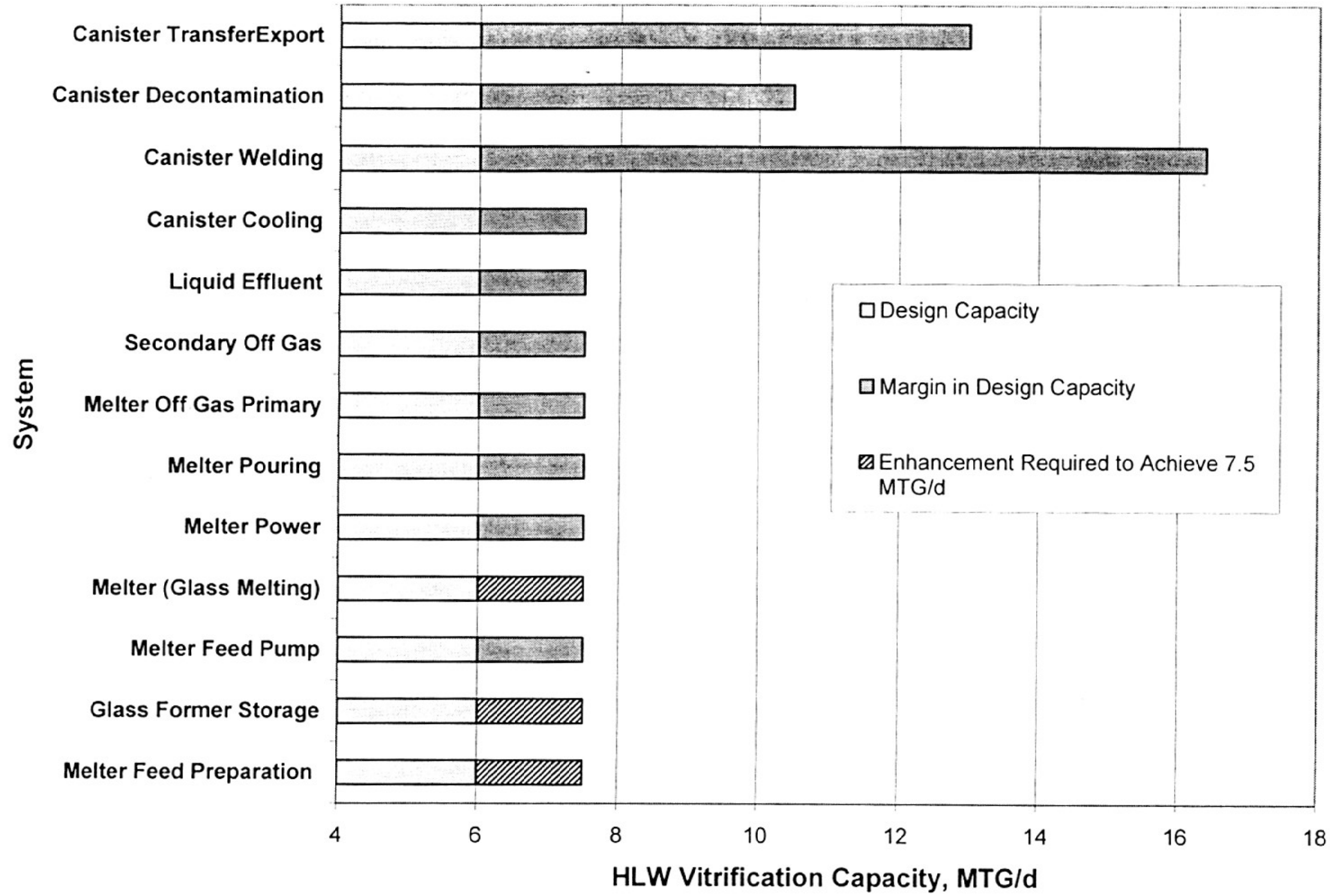

Figure 3 Summary of Design Capacities, Design Margin and Capacity Enhancements Needed for Each of the Major process and Mechanical Systems in the HLW Vitrification Facility to support a 7.5 MTG/d Production Rate

4.0 Summary of Open Items

Table 2 Summary of ORP Open Items Identified in the HLW Vitrification Facility Design Oversight

Open Item Number	Open Item
1	ORP should evaluate the results of the studies being conducted by both BNI and the Tank Farm Contractor to resolve the design capacity limitations associated with the WTP Ultra Filtration System, to ensure that the washed HLW solids projected to be produced can support the production of HLW glass at 7.5 MTG/d, using waste loading limits based upon a glass properties model.
2	ORP should further evaluate the need for, and, if required, implement a more rapid analytical technique, such as Laser Ablation, to characterize the melter feed to support continuous melter operations at 7.5 MTG/d. This evaluation should be conducted at the time of HLW Vitrification Facility commissioning.
3	ORP should evaluate the HLW Canister Product/Process control strategy with the objective of reducing the sampling requirements and operational costs to qualify the HLW product.
4	ORP should continue to monitor the progress and adequacy of BNI efforts to establish the HLW Feed Process-ability Specification as required for the HLW Product/Process Control Strategy.
5	ORP should monitor and evaluate the WTP melter/film cooler test results obtained during cold and hot commissioning to ensure that the melter design provided is capable long term maintenance free operation.
6	ORP should evaluate the production capability of the WTP melter during cold and hot commissioning phases of the BNI Contract. Based upon these results additional R&T Testing of the bubbler design and layout, and modifications to the second HLW melter to improve production capacity to 3.75MTG/d should be identified.
7	Following hot commissioning ORP should require the WTP Operations Contractor to update the heat load and temperature based on actual operating conditions and establish if any adjustments in HVAC in the pour cave or finishing line would be required to increase the glass production rate to 3.75 MTG/day per melter.
8	ORP should conduct an additional detailed design oversight on the Operational Research Model used to estimate plant availability to further evaluate the issues identified in the HLW Vitrification facility design oversight. The scope of this oversight should include all major WTP facilities.

References

1. 24590-WTP-DB-ENG-01-001, Rev 1B, "WTP Basis of Design", June 3, 2004, Bechtel National, Inc., Richland Washington.

2. 04-WED-024, "Summary of Actions form the US Department of Energy, Office of River protection (ORP) Oversight of Pretreatment (PT) Pant Ultra filtration Process (UFP) System", June 06, 2004.

3. 24590-WTP-RPT-PO-03-045, Rev o, OR Assessment Report, Bechtel National, Inc., Richland Washington.

4. 24590-HLW-3YD-HSH- {TBD}, System Description for High Level Waste Vitrification Facility Melter Support System, to be prepared in early 2005

5. 24590-101-TSA-W000-0009-162-00001, Rev 00A, (REP-RPP-069), "Investigation of Glass Bubbling and Increased Production Rate", October 28, 2004, Bechtel National, Inc., Richland Washington.

E-STARS™ Report
Task Detail Report
01/04/2005 0921

TASK INFORMATION

Task#	ORP-WTP-2004-0230		
Subject	CONCUR: (04-WED-088) TRANSMITTAL OF DOE ORP DESIGN OVERSIGHT REPORT ON HLW VITRIFICATION FACILITY TREATMENT CAPACITY, D-04-DESIGN-008		
Parent Task#		**Status**	CLOSED
Reference	04-WED-088	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	12/20/2004 1502	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you. bcc: MGR RDG File WTP OFF File J. J. Short, OPA D. H. Alexander, WED W. F. Hamel, WED E. H. Randklev, WED P. T. Furlong, WPD J. R. Eschenberg, WTP L. F. Miller, WTP RECORD NOTE: Scan background information into RMIS and file with letter and attachment.		

ROUTING LISTS

1	Route List	Inactive
	• Alexander, Donald H - Review - Cancelled - 01/04/2005 0921	
	• Hamel, William F - Review - Concur with comments - 12/22/2004 1357	
	• Eschenberg, John R - Review - Concur - 12/22/2004 1356	
	• Schepens, Roy J - Approve - Approved with comments - 01/04/2005 0915	

ATTACHMENTS

Attachments	1. 04-WED-088.DHA.Attach.DOC 2. 04-WED-088.DHA.Oversight Rpt on HLW.doc

COMMENTS

Poster	Hamel, William F (Almaraz, Angela) - 12/22/2004 0112
	Concur
	Don signed for Bill on 12/21/04.
Poster	Schepens, Roy J (Deutsch, Virgene A) - 01/04/2005 0901
	Approve
	Signed by Shirley Olinger in Schepens' absence.

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Poster	Almaraz, Angela (Almaraz, Angela) - 01/04/2005 0901
	CLOSED
	Don signed the hard copy on 12/20/04.

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

E-STARS™ Report
Task Detail Report
12/20/2004 0309

TASK INFORMATION

Task#	ORP-WTP-2004-0230		
Subject	CONCUR: (04-WED-088) TRANSMITTAL OF DOE ORP DESIGN OVERSIGHT REPORT ON HLW VITRIFICATION FACILITY TREATMENT CAPACITY, D-04-DESIGN-008		
Parent Task#		**Status**	Open
Reference	04-WED-088	**Due**	
Originator	Almaraz, Angela	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	12/20/2004 1502	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal

Instructions

Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you.

bcc:
MGR RDG File
WTP OFF File
J. J. Short, OPA
D. H. Alexander, WED
W. F. Hamel, WED
E. H. Randklev, WED
P. T. Furlong, WPD
J. R. Eschenberg, WTP
L. F. Miller, WTP

RECORD NOTE: Scan background material into RMIS and file with letter and attachment.

ROUTING LISTS

1 Route List Active

- Alexander, Donald H - Review - Awaiting Response 12/20/04 EHR 12/21/04
- Hamel, William F - Review - Awaiting Response for WH 12/21/04
- Eschenberg, John R - Review - Awaiting Response 12/21/04
- Schepens, Roy J - Approve - Awaiting Response 1/03/05

ATTACHMENTS

Attachments
1. 04-WED-088.DHA.Attach.DOC
2. 04-WED-088.DHA.Oversight Rpt on HLW.doc

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

Background to
04-WED-088

Waste Treatment Plant
HLW Vitrification Facility Treatment Capacity

D-04-DESIGN-008

AUDIT NOTES

December 2004

WED:WFH
December 20, 2004

Waste Treatment Plant
HLW Vitrification Facility Treatment Capacity

D-04-DESIGN-008

AUDIT NOTES

December 2004

Office of River Protection
Richland, Washington

AUDIT NOTES

The following sections provide the audit notes compiled by the ORTP Oversight Team in the course of reviewing the WTP HLW Vitrification Facility Treatment Capacity.

Sections are provided as follows:

Section A: HLW Melter Feed Preparation System
Section B: HLW Melter System
Section C: HLW Melter Off-gas Treatment System
Section D: Canister Processing and Handling Systems
Section E: Melter Cell and Canister Line Maintenance Systems
Section F: Hot Cell Solid Waste Management Systems

AUDIT NOTES

Section A
HLW MELTER FEED PREPARATION SYSTEM

Introduction

The systems used to prepare and deliver the HLW melter feed that were reviewed were:

- System Description for HLW Melter Feed (System HFP)
- System Description for Glass Former Reagents System (GFR)
- System Description for HLW Lag Storage and Feed Blending Process System (HLP)

The process steps currently planned to prepare and qualify the HLW Melter feed are described in the "IHLW Product Compliance Plan" and are summarized below. A recent assessment of the production capability of the HFP System is also provided in "HLW Melter Feed and Feed Preparation Vessel Utilization and Time Cycle Evaluation". (Note: This current Design Oversight will not evaluate the adequacy of the HLW product compliance strategy.)

A schematic of the major components of the HLW feed preparation system and compliance strategy for Immobilized High-Level Waste (IHLW) compositional control is presented in Figure A.1. The HLW melter feed preparation consists of 2 lag storage vessels (HLP-VSL-00027A/B) used to store HLW washed and leached solids and a Blend Vessel (HLW-000028) located in the Pretreatment facility. These vessels are used to prepare a HLW feed batch for transfer to the HLW Vitrification facility. Within the HLW Vitrification facility the HFP System is used to prepare the final melter feed. The HFP System includes the Melter Feed Preparation Vessels (MFPV) (HFP-VSL-00001 A/B), the Melter Feed Vessels (HFP-VSL-00002 A/B) and two ADS feed pumps for each MFV. Each HLW melter is supported by is own MFPV, MFV and 2 ADS feed transfer pumps. The Glass Former Feed Hopper (GFR-TK-00025) is used to transfer glass forming chemicals to the MFPV as part of the Glass Formers Reagent (GFR) system.

Melter Feed Make-up and Process Control Strategy

Glass Composition Compliance Strategy

The HLW feed make-up and process control strategy during production relies on analysis of samples from the MFPV. Characterization of the MFPV will consist of sampling after each batch transfer of waste from the Pretreatment facility to confirm that the HLW feed can be vitrified within an established glass composition region after GFC addition, to confirm in advance of vitrification that specific limits for compliance with HLW glass product specifications are not exceeded, and to provide sufficient composition information to calculate the correct glass former chemical (GFC) addition.

Following GFC addition, the MFPV will be re-sampled to verify the GFCs have been added correctly, determine chemical composition for composition reporting during production and product consistency control. A mass balance process model is planned to be developed by BNI to correlate MFPV composition with glass product composition. This MFPV sample is a compliance hold point. Thus, the waste will not be transferred to the MFV until analytical results confirm that a compliant glass product can be formulated.

The correlation between the waste feed composition and target glass formulation is established during development testing. The GFC quality (e.g. composition and solids characteristics) will be controlled by a GFC process specification. The waste feed composition will be deemed acceptable when it is confirmed that the projected glass composition has properties that meet specified requirements. The resultant waste feed will then be transferred to the melter feed vessel (MFV).

The radionuclide composition for production reporting will be based on MFPV sampling and analysis. Of the potential 18 MFPV batches for a given HLW blend vessel (Vessel located in Pretreatment used to prepare the HLW concentrate) inventory, all batches will be sampled and analyzed for non-radioactive constituents and all batches will be analyzed for a minimal list of radioactive constituents. One of these MFPV batches will be sampled and analyzed for a full set of radionuclide constituents. This sample result from one of the MFPV batches for full radionuclide analysis is not a compliance hold point.

There will be no regular sampling of the MFV. The waste feed is transferred from the MFV to the melter where it is processed into glass, and subsequently poured into canisters.

Glass product samples will not be taken on a regular basis. However it is planned to obtain glass samples from the top of the canister in the Canister Handling Cave (See Appendix D). These sample analyses may be used to: 1) verify chemical composition and radionuclide inventory, 2) validate the product composition models, and 3) report hazardous waste toxicity characteristic leaching procedure (TCLP) results (if required by the delisting petition). Product samples may be taken more frequently during commissioning operations to demonstrate the correlation between waste feed preparation and product sample compositions.

Process Control

Process control during production will achieved as follows:

- Controlling allowable composition amount of HLW feed from pretreatment
- Controlling allowable composition, blend and total amount of GFCs per batch
- Use of a glass formulation algorithm
- Specification of the operating conditions for the MFPV and MFV

A glass formulation algorithm will be used to determine the GFC batch additions needed to meet the nominal operating composition. An entire GFC batch will be transferred to the MFPV for blending with the HLW feed concentrate. The GFC batching process is not considered to be a part of the WASRD compliance strategy because correct GFC additions are confirmed by MFPV sampling. Nonetheless, a GFC process acceptance specification will be developed in conjunction with the GFC procurement QA requirements to ensure that the composition of the GFCs is known and controlled prior to use (particularly with respect to contaminants). The mixture in the MFPV will be agitated to form a well-mixed melter feed slurry. A set of samples will be taken and analyzed to verify proper GFC addition. The glass property composition model developed will be used to project the information needed for the Production Records. The slurry will then be transferred to the MFV. The volume of slurry transferred will be confirmed by level measurements in the sending and receiving vessels. The slurry from the MFV will then be fed on a continuous basis to the melter for vitrification. The MFV is not sampled during normal operations and is not a compliance hold point.

The operation of the vitrification process will include the use of a HLW process specification. This specification will set the allowable limits for the composition of the HLW waste feed transferred form the Pretreatment facility to the HLW Vitrification facility. The specification will be based upon the set of composition to glass property correlation boundaries represented by an acceptable HLW glass composition region.

BNI plans on developing and validating a set of process control requirements prior to production operations. The requirements will be used to ensure that the waste feed makeup operations will produce acceptable melter feeds. The control system will be designed to prevent errors in combining the HLW feed and GFCs. In the unlikely event that an error in the melter feed composition occurs, the MFPV batch composition would be adjusted with GFCs or diluted and re-analyzed.

The following evaluates the capabilities of the HLW Feed Preparation Systems in the following areas:

- HLW Feed Preparation and Qualification Design Capacity
- ADS Pump Design Capacity
- Glass Former Addition System

HLW Feed Preparation and Qualification Design Capacity

Conclusions:

BNI has not clearly defined the requirements for the HLW concentrate to be produced in the Pretreatment facility and to be delivered to the HLW Vitrification facility to ensure that the IHLW product will meet the product requirements as defined by the WTP Contract in terms of waste loading, or the requirements defined in the Office of Civilian Radioactive Waste Management in the Waste Acceptance Requirements Document (WASRD). This lack of definition in the interface requirements between Pretreatment and HLW Vitrification continues to place the design of the WTP process system's at risk.

The design of the Ultra-filtration System to prepare washed and leached solids, and the requirements to ensure acceptable melter feed concentrations have resulted in a HLW feed preparation system that marginally meets requirements and may not allow ORP to meet more aggressive treatment goals. The uncertainty in the performance of the process equipment systems places at risk, the ability of the feed system to support effective treatment of the tank waste compositions. The major uncertainties include: the ability of the UFP System to deliver a sufficient concentration, and production rate, of washed and leached solids; and the degree of dilution of the HLW concentrate that will occur due to water additions from transfer line flushing, demister flushing, and GFC dust control.

The HLW Feed Preparation System is capable of producing sufficient quantities of qualified HLW feed, to support HLW Melter operations at a minimum of 350 gram-oxide/liter, provided that the UFP System produces solids with a concentration of 17 to 20 wt%, and assuming an average HLW waste loading of 35 wt% using the Glass Properties Model to determine waste loading. The achievement of higher waste loadings (e.g. 40 wt% as assumed in the ORP Stretch Case for this study) will require that the UFP System solids concentrations be increased to a minimum of 19 wt% to maintain a melter feed concentration of at least 350 gram-oxide/liter. The ability to operate the UFP System such that washed and leached solids are provided at concentrations greater than 20 wt% and support a production rate equivalent to 7.5 MTG/d is uncertain based upon the testing data developed to date, and the current issues associated with the design capability of the UFP System.

The use of Non-Dilute Dissolution as an analytical technique to characterize the melter feed appears adequate to support HLW Vitrification facility operations at 6 MTG/d provided that the prepared Melter Feed Preparation Vessel (MFPV) batch size be at least 5000 gallons and the glass yield be at least 350 gram-oxide/liter. A more rapid analytical technique, such as the Laser Ablation will be needed to characterize the melter feed and support continuous melter operations at 7.5 MTG/d. This assumes that the MFPV batch size is at least 5000 gallons and the glass yield is at least 350 gram-oxide glass/liter feed.

The sampling and analysis requirements for the WTP facility are greater than those of the DWPF and former WVDP operations when considered on a unit basis, either MTG produced or canister. ORP should evaluate the HLW Product/Process Control strategy following the completion of the BNI contract to reduce HLW Vitrification facility operations complexity and cost.

Discussion

BNI has recently evaluated the design capacity of the HFP System as a result of removing the HLW Concentrate Receipt Vessels (CRVs) from the HLW Vitrification facility. This assessment (24590-HLW-ES-PR-04-000) made a number of conclusions and recommendations, most important to this Oversight are the following:

- A minimum glass yield of 325 gram-oxide/liter of melter feed is needed to ensure continuous melter operations under a range of batching scenarios considered. These scenarios considered Pretreatment facility HLW solids concentration (12.5 to 20 wt%), glass waste oxide loading (20 to 40 wt%), glass yield concentrations (250 to 650 gram oxide/liter) and various batch sizes and assumptions on HLW feed make-up and analysis times.

- The HLW concentrate solids concentration should be at least 20 wt%.

- A HLW MFPV batch volume of 5000 to 5200 gallons is required to ensure no interruption in HLW glass production.

- The use of Laser Ablation for elemental analysis should be explored further since it is estimated to significantly reduce the analytical time and reduce analytical uncertainty

The Oversight Team is in agreement with these recommendations. The result of this assessment (24590-HLW-ES-PR-04-000) is also used with other information to make additional judgments on the capability of the HLW Vitrification facility.

Minimum Required Solids Concentration from Pretreatment Facility

BNI calculations (24590-HLW-M4C-HFP-00002, 24590-HLW-M4C-HFP-00003) and DM-1200 melter testing information can be used to estimate the minimum solids concentration from the Pretreatment facility to achieve the HLW melter design capacity of 3 MTG/d/melter. (This is done because this work has not been completed by BNI.) Figure A.2 shows graphically information obtained from parametric calculations (24590-HLW-M4C-HFP-00002, 24590-HLW-M4C-HFP-00003) that can be used to relate glass yield per liter of melter feed to waste oxide loading in the glass at various solids concentration generated in the Ultra-filtration system. This figure also has minimum glass yield concentrations identified. A minimum glass yield of 350 gram oxide/liter corresponds to the minimum concentration to allow the HLW melter to operate with a stable cold cap (personal communication with JM Perez of BNI-WGI, November 17, 2004). Based upon recent DM-1200 melter tests at the Vitreous State Laboratory (VSL) it was determined that at feed rates scaled to the 3 MTG/d WTP melter the glass yield needed to be greater than 350 gram oxide/liter to maintain stable melting and consistent melter plenum temperatures. In addition, a minimum concentration of 325 gram oxide/liter is noted based upon the assessment of the capacity of the HLW feed preparation system (24590-HLW-ES-PR-04-0001). Below 325 gram oxide/liter HLW melter feed cannot be prepared in sufficient time to maintain continuous melter operations at 3 MTG/d/melter.

Figure A.2. can also be used to determine the minimum acceptable HLW solids concentrations from the Pretreatment facility. Assuming that the HLW solids are diluted with waste by a total of 3 wt%, and the glass waste loading is 35 wt% waste oxide, then the minimum solids concentration from Pretreatment must be ~17wt% or greater. (This result should be confirmed during resolution of the design issues in the Pretreatment facility and in the preparation of a process-ability specification for the HLW Vitrification facility.)

The WTP Contract is based upon specific concentration values, identified in *Specification 1, Immobilized High-Level Waste*, that specify the minimum glass waste loading based upon chemical constituents of the waste. Based upon historical estimates, the average waste loading for the WTP Contract over the treatment mission would be about 28 wt%. ORP's System Plan (ORP-11242) is based upon the use of a Glass Properties Model as a means to project glass volume to estimate HLW glass loading. The System Plan estimates that the average glass waste loading would be about 35 wt% over the RPP mission. Over the RPP Mission, the glass loading assuming the Glass Properties Model is about 25% higher than the WTP Contract specifications. However, the case considered in this Design Oversight ("8000 in 2025") assumes that the waste loading is about 40 wt%. The increase in HLW glass waste loading requires that the solids concentration from the UFP System be increased.. This effect is illustrated in Figure A.2.

Capacity of the Melter Feed Preparation System

As noted, BNI has recently completed a study to evaluate the impacts associated with the removal of the HLW Concentrate Receipt Vessels from the HLW Vitrification Facility and the corresponding ability of the HLW Vitrification to prepare melter feed (24590-HLW-ES-PR-04-0001, Rev 0). The assumptions and results from this study were used to verify that the current design is adequate and can be used to forecast if the current design can be used to support expanded vitrification operations. The time estimates for the melter feed preparation activities presented in Table A.2 (minimum, maximum, and average) were used in a Crystal Ball analysis to forecast the probability-time distribution for the application of two analytical techniques in the preparation of the melter feed. These two analytical techniques were Non-Dilute Dissolution and Laser Ablation. Time estimates for the completion of the analyses were abstracted from 24590-HLW-ES-PR-04-0001. The results of this analysis are summarized in the Table below and indicate the following:

- Non-Dilute Dissolution will support the production of HLW glass at a design rate of 6 MTG/d at prepared batch volumes of 5000 and 5200 gallons.
- Non-Dilute Dissolution will not support the production of HLW glass at a design rate of 7.5 MTG/d at prepared batch volumes of 5000 and 5200 gallons due to uncertainties in the time estimates for the melter feed preparation activities.
- A more rapid analytical technique, such as Laser Ablation, will be required for melter feed analysis to support continuous operation of the HLW melter assuming a make-up batch volume of 5000 t0 5200 gallon.

Table A.1 Assessment of the Ability of the HLW Vitrification Facility to Prepare Melter Feed.

Parameter	Lower Recommended Bound for MFPV Batch	Higher Recommended Bound for MFPV Batch
Prepared Batch Size (gallon)	5000	5200
Glass Yeids/liter (gram-oxide/liter)	350	350
Glass Equivalent/Batch (kilogram)	6781	7053
Time Equivalent of Feed Batch at 6 MTG/d (hour)	54.3	56
Time Equivalent of Feed Batch at 7.5 MTG/d (hour)	43.4	45.1
Crystal Ball Assessment of Feed Preparation Times	**Non Dilute Dissolution**	**Laser Ablation**
Minimum Preparation Time-10% Probability, (Hours)	38.7	32.6
Mean Preparation Time, (Hours)	42.4	35.4
Maximum Preparations Time 90% Probability, (Hours)	46.1	38.7

Table A.2 is a comparison of specific design and process features of the DOE HLW Vitrification facilities at the West Valley, New York Site (West Valley Demonstration Project), Savannah River Site (Defense Waste Processing Facility) and WTP. This data illustrates that the amount of HLW feed that is prepared and qualified compared to the glass production rate is greater for the WVDP and DWPF than the WTP. The result is that the "effort" to qualify a HLW canister is 2 to 3 times greater for the WTP. This issue has been addressed with BNI in formal correspondence associated with a review of the HLW Waste Compliance Plan. The Oversight Team believes that the current HLW compliance approach can be simplified thereby reducing the number of required compliance samples which will reduce the operational complexity and cost of HLW glass production.

ADS Pump Design Capacity

Conclusion

The ADS pump system is capable of supporting a melter feed rate equivalent to a maximum of >6 MTG/d for each melter, assuming a glass yield of 350 gram oxide/liter and an operating stroke frequency of 30 seconds. The operating lifetime of the ADS pump decreases with decreasing operating stroke frequency. The ADS Pump design will not limit the HLW glass production rate in the production range of 3.75 MTG/d/melter.

Discussion

Each MFV is equipped with two ADS pumps. Each pump supplies a feed nozzle. The feed nozzles are spatially arranged on the melter lid to provide uniform coverage of feed over the melt pool. During normal operation both ADS feed pumps are used to supply feed to the melter. For short periods of time it is acceptable to use the one ADS feed system. However prolonged feeding of a portion of the melt surface will reduce glass production.

The sizing of the Air Displacement Slurry (ADS) pump system is described in 24590-QL-HC4-W000-00011-04-00270. The capacity of the ADS pump is affected by the pump chamber volume, the stroke time and the glass yield per liter of waste.
Using the calculation method from the sizing calculation it is possible to determine an expected capacity range for the ADS pump. Table A.3 summarizes the glass yield and estimated ADS pump capacity for three different pump stroke frequencies. This data also estimates the lifetime of the ADS pump assuming that the ADS pump is capable of 1,280,000 stroke cycles (24590-QL-HC4-W000-00011-04-00270).

Assuming a stroke cycle of 30 seconds and a glass yield of 400 gram oxide/liter the ADS pump system (2 pumps) is capable of supplying the melter at 12 MTG/d equivalent. These results show that the ADS pump design is capable of supporting any reasonable glass production rate required and thus is not a capacity limitation. However, the operational life may decrease with an increased ADS pump rate. The data in Table A.3 can be simply extrapolated to determine glass yield stoke frequency and pump life.

Table A.3 Comparison of ADS Pump Operating Parameters

Solids Concentration, gram glass/liter	Max capacity at 30 sec/stroke, MTG/d/pump	Min capacity, 100 sec/stroke, MTG/d/pump	Min capacity, 300 sec/stroke, MTG/d/pump
325	4.89	1.47	0.49
350	5.27	1.58	0.53
400	6.02	1.81	0.60
550	8.27	2.48	0.83
Pump Life, years	1.2	4.0	12.0

Glass Former Addition System

Conclusion

The Glass Former Reagent (GFR) system will be adequately sized to support the expanded HLW Vitrification capacity of 7.5 MTG/d design capacity (assumes production capacity of 5.2 MTG/d), following the expansion of the capacity to support LAW Vitrification at 45 MTG/d.

Discussion

The Glass Former Reagent (GFR) system is described in 24590-BOF-3YD-GFR-00001. The sizing calculation for each of the chemical reagent batches is provided in 24590-BOF-MTC-GFR-00002. The GFR System was designed to support the operation of the HLW Vitrification facility at 6 MTG/d and the LAW Vitrification facility at 30 MTG/d consistent with the WTP Contract and WTP Basis of Design. The ORP is however interested in enhanced LAW Vitrification facility operations to a design rate of 45 MTG/d, and an assumed production rate of 34 MTG/d. Assuming that the availability of the HLW Vitrification facility is 70%, the treatment rate for 615 canisters per year would be 5.2 MTG/d, or a design capacity of 7.5 MTG/d.

Figure A.3 shows the capacity in days of production for the 13 glass former batch sizes (translated into minimum hoppers capacity). Note that at the expanded capacity the silica would be contained in two hoppers having a size of 8500 and 3500 cubic feet. Three cases are presented in Figure A.3, these are the:

- Days of Hopper Storage at the Design Capacity of 45 MTG/d LAW Vitrification and 7.5 MTG/d HLW Vitrification assuming no contingency in the GFC Volume.

- Days of Hopper Storage at the Design Capacity of 45 MTG/d LAW Vitrification and 7.5 MTG/d HLW Vitrification assuming a 25 % contingency in the GFC Volume. This case assumes that there is 25% contingency in the batch volume to account for variations in the fill characteristics of the hopper.

- Days of Hopper Storage at the Treatment Capacity of 34 MTG/d LAW Vitrification and 5.2 MTG/d HLW Vitrification.

In all cases, there is at least one week of storage capability on the WTP Site for GFCs. This is assumed to be adequate based upon requirements to maintain continuous operations in the LAW and HLW Vitrification facilities. It is also assumed that in the expanded GFC system design that ORP will add a third blending hopper to support the preparation of the glass batches.

The current procurement specification for the GFR system required that the facility have an availability of 90%. The vendor is to provide an analysis of this capability as part of the procurement deliverables. Note: The procurement of the GFR System has just been awarded at the time of this Oversight.

The GFC batch sizes (e.g. minimum hopper sizes) each have a different size expressed as days of storage. This is a result of the methodology used in the GFC batch sizing calculation. The calculation approach required that the larger of two capacity estimates be used as a basis for sizing. These two considerations were the greatest of: a) 10 days of storage for the vitrification facilities or b) 5 days of storage plus a 48,000 lb truck load. As a result, there are capacity size ranges between 8.6 and 35.2 days for the production rate capacity scenario.

References

1. 24590-HLW-ES-PR-04-0001, Rev 0, "HLW Melter Feed and Feed Preparation Vessel Utilization and Time Cycle Evaluation", November 11, 2004, Bechtel National Inc., Richland, Washington
2. 24590-HLW-M4C-HFP-00002, Rev 0, "Parametric Study of Oxide Loading in HLW Melter Feed", February 28, 2002, Bechtel National Inc., Richland, Washington
3. 24590-HLW-M4C-HFP-00003, Rev 0, "Oxide Loading in HLW Melter Feed", February 28, 2002, Bechtel National Inc, Richland, Washington
4. 24590-HLW-3YD-HFP-00001, "System Description for HLW Melter Feed (System HFP)", January 22, 2003, Bechtel National, Inc., Richland Washington.
5. **Error! Unknown document property name.**, Rev **Error! Unknown document property name.**, "IHLW Product Compliance Plan" December 2004 Draft, Bechtel National, Inc., Richland Washington.
6. 24590-QL-HC4-W000-00011-04-00270, Rev 00A, "HLW ADS Pump Sizing", June 14, 2004, Bechtel National, Inc., Richland Washington.
7. 24590-BOF-MTC-GFR-00002, "GFR System Equipment Calculation for the '2+2' Option", March 25, 2004, Bechtel National, Inc., Richland Washington.
8. 24590-BOF-3YD-GFR-00001, "System Description for Glass Former Reagents System (GFR)", March 26, 2003, Bechtel National, Inc., Richland Washington.
9. 24590-PTF-3YD-HLP-00001, "System Description for HLW Lag Storage and Feed Blending Process System (HLP)", September 11, 2003, Bechtel National, Inc., Richland Washington.
10. ORP-11242, Rev 2.0, "River Protection Project System Plan", September 2003, Office of River Protection, Richland Washington.

Table A.2 Summary of Activities and Expected Durations for the Preparation of the HLW Melter Feed (Data abstracted from 24590-HLW-ES-PR-04-0001, Rev 0)

Activity	Minimum Time, min	Maximum Time, min	Average Time ,min
Prepare for HLW Concentrate Transfer	10	60	30
Initial MFPV Vessel Level Determination	15	45	30
Waste Transfer	14	33	23.5
Transfer Line Flush	5	15	10
Final MFPV Vessel Level Determination	15	45	30
Transfer to HLW Vitrification	59	198	123.5
Waste Sampling and Analysis for GFC Addition			
Initial Mixing	15	45	30
Initial Sampling	60	60	60
Sampling for GFC Addition	75	105	90
Sample Prep and Analysis			
Non-Dilute Dissolution	360	600	480
Laser Ablation	300	420	360
Data Analysis and Verification	60	180	120
NDD Sample Prep/Ana-Initial	420	780	600
LAMS Sample Prep/Ana-Initial	360	600	480
Glass Former Batch Preparation			
Weight and Convey Glass Formers	60	90	75
Prepare for GFC Transfer	10	30	20
Blended GFC Transfer	70	120	95
GFC Weight Check	10	30	20
GFC Transfer to MFPV	72	150	105
GFC Addition Time	222	420	315
Waste Sampling and Analysis for MFPV Verification			
Initial Mixing	15	45	30
Initial Sampling	120	120	120
Sampling for GFC Addition Verification	135	165	150
MFPV Batch Verification	270	330	300
Sample Prep and Analysis			
Non-Dilute Dissolution	720	960	840
Laser Ablation	420	660	540
Data Analysis and Verification	60	180	120

Activity	Minimum Time, min	Maximum Time, min	Average Time ,min
NDD Sample Prep/Ana-Final	780	1140	960
LAMS Sample Prep/Ana-Final	480	840	660
Blended HLW Melter Feed Transfer			
Prepare for Blended Feed Transfer	10	30	20
Waste Transfer	102	132	117
Transfer Line Flush	5	15	10
Transfer Time MFPV-MFV	117	177	147
Total Time NDD Analysis, minute (hour)	1749 (29.2)	2787 (46.5)	2262 (37.7)
Total Time LAMS, minute (hour)	1389 (23.2)	2307 (38.5)	1842 (30.7)

Table A.3 Comparison of Feed Preparation and Compliance Sampling Only for DOE Waste Vitrification Projects

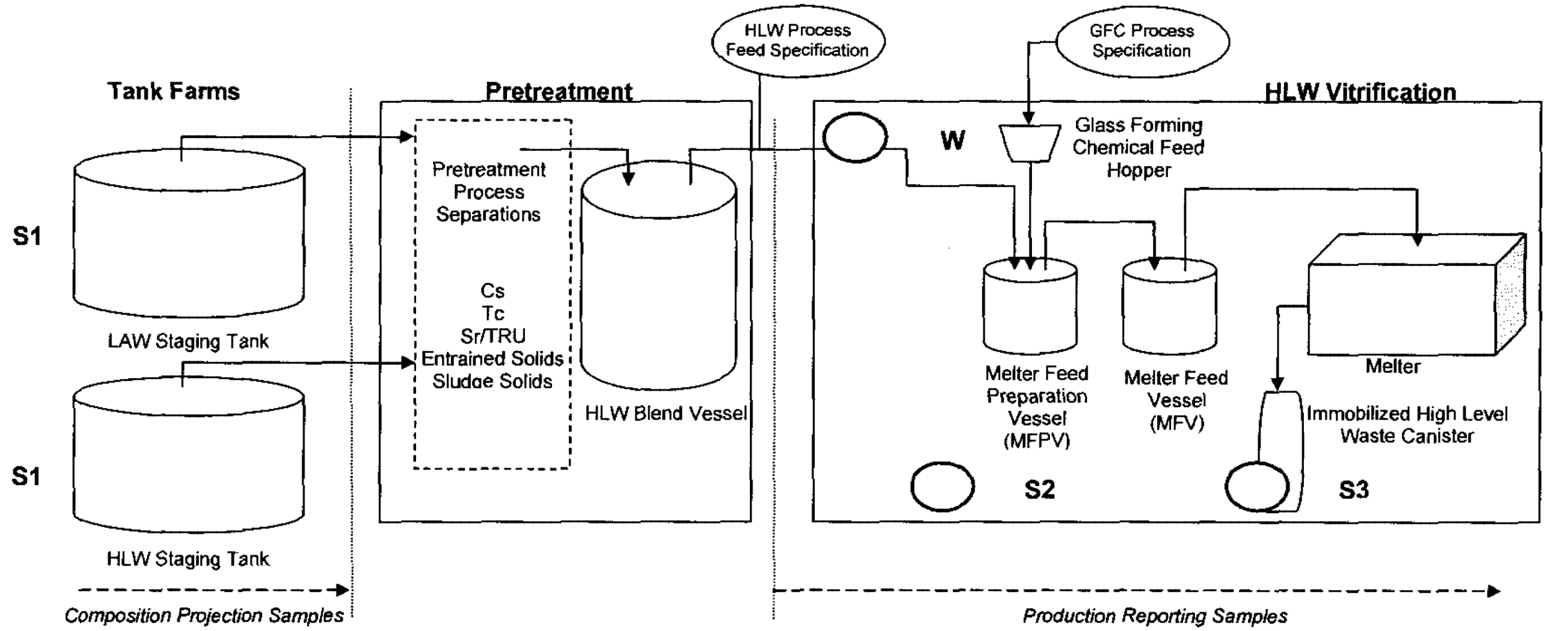
DOE Project	HLW Vitrification Capacity, MTG/d	HLW Waste Make-up Tank Working Capacity, gal, (m^3)	HLW Melter Feed make-up Tank Working Batch Capacity, gal, (m^3)	Nominal HLW Melter Feed Concentration, (gram oxide/liter)	Time Equivalent of HLW Feed Batch-Design Basis, (hr)	Number of Melter Feed Batches/year	HLW Compliance Samples/Year	Sample Analyses/MTG Produced, (Canister)
DWPF	2.0	4500 (17)	7500 (28)	400	140	64	580[a]	0.8 (1.6)
WVDP	0.7	5550 (21)	5165 (19.5)	370-500	182-247	44	396[a]	0.32 (0.64)
WTP-6 MTG/d	2 at 3.0 MTG/d	5500 (21)	5500 (21)	400	60	289	3616[b]	1.65(5.1)
WTP-7.5 MTG/d	2 at 3.75 MTG/d	5500 (21)	5500 (21)	400	48	362	4520[c]	1.65(5.1)

Notes:

a. It is assumed that the DWPF and WVDP take 9 samples per batch for each of the HLW waste feed make-up and HLW melter feed makeup tanks.

b. The WTP sample and analysis requirements are based upon the 24590-WTP-PL-PR-04-0001, Rev 0., "Integrated Sampling and Analysis Requirements Document", draft, November 2004. It is assumed that the HLW feed glass yield is 400 gram oxide per liter and the batch size make-up is 5000 gallons. Four samples are taken per batch to support glass former addition and 8 samples are used to verify the glass former addition. Every 16 batches an additional 8 samples are taken to support radionuclide reporting. The compliance samples include the initial samples because they are designated as a process hold point in the ISARD. The WTP Project estimate from the ISARD is 3842 samples per year.

c. Estimate based on scaling with WTP Design Basis.



S	Sample Point
W	Weight Measurement

<u>Composition Projection Samples</u>
HLW and LAW Feed Staging Tank Samples **S1** (ICDs 23, 19, and 20) used for:

- Chemical Projections (WASRD specification 5.4.1(B)(1))
- Radionuclide Projections (WASRD specification 5.4.1(B)(2))

<u>Production Reporting Samples</u>
MFPV **S2** used for

- Chemical Composition Reporting (WASRD specification 5.4.2)
- Product Consistency Reporting (WASRD specification 4.8.1(B)
- Hazardous Waste Regulation Compliance (WASRD specification 4.2.2)
- Radionuclide Reporting (WASRD specifications 5.4.2)
  Radionuclide Reporting (**S2**): One complete radiochemical analysis (Sample **S2**) from one of the series of MFPV batches corresponding to a given HLW blend vessel makeup batch. Short-list radiochemical analyses for initial MFPV batch samples.
- On DOE-ORP request: Glass Sample **S3** used for Process/Product Control model validation (WASRD specification 4.8.1(B))

HLW Process Specification used to ensure HLW Feed from pretreatment will produce a WTP contract compliant waste form.
GFC Process Specification used to ensure composition of Glass Forming Chemicals is known and controlled.

Figure A.1 HLW Process/Product Control Compliance Strategy

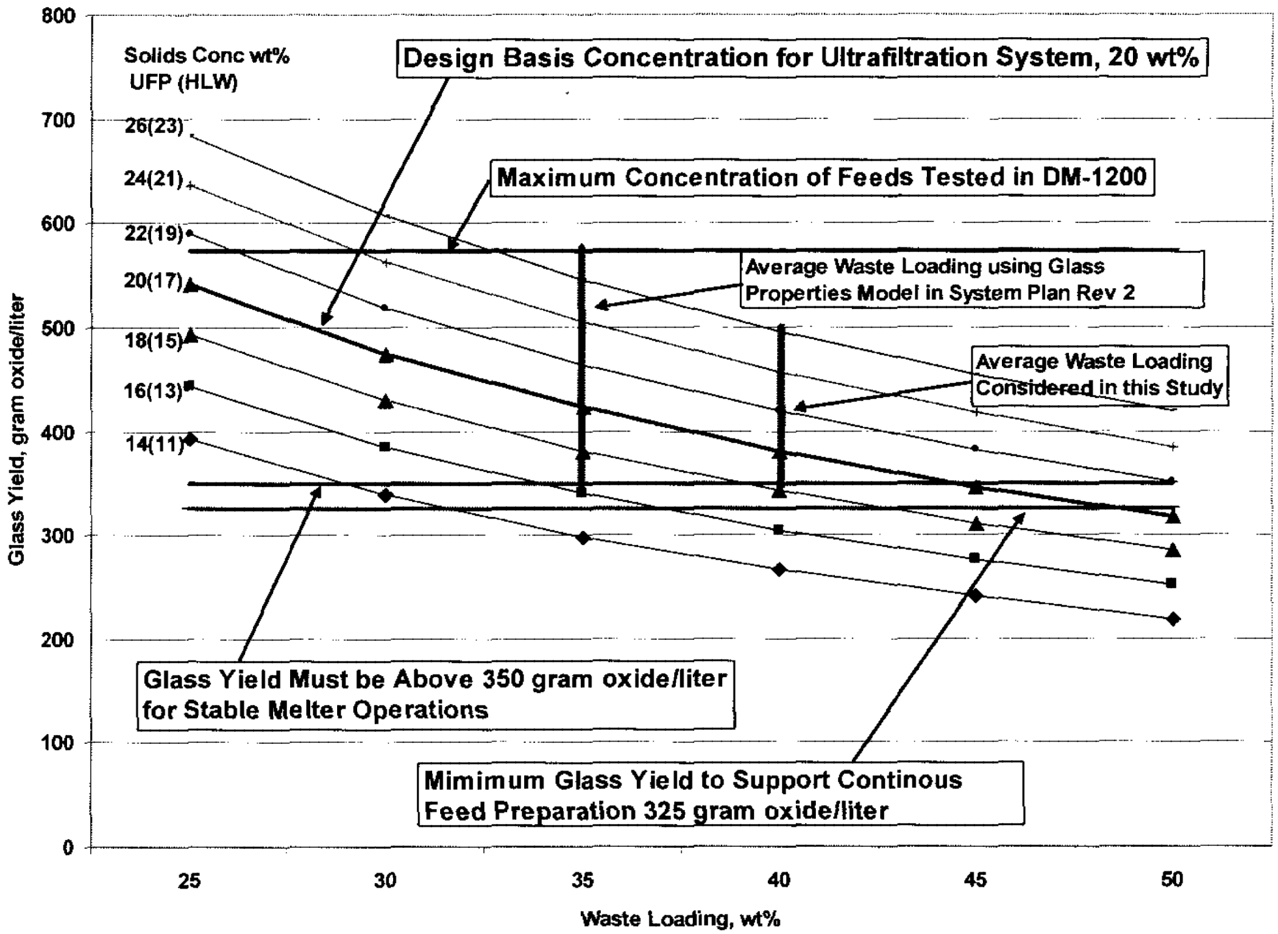


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Figure A.2 Pretreatment Solids Loading, Glass Waste Loading and Glass Yield Relationships

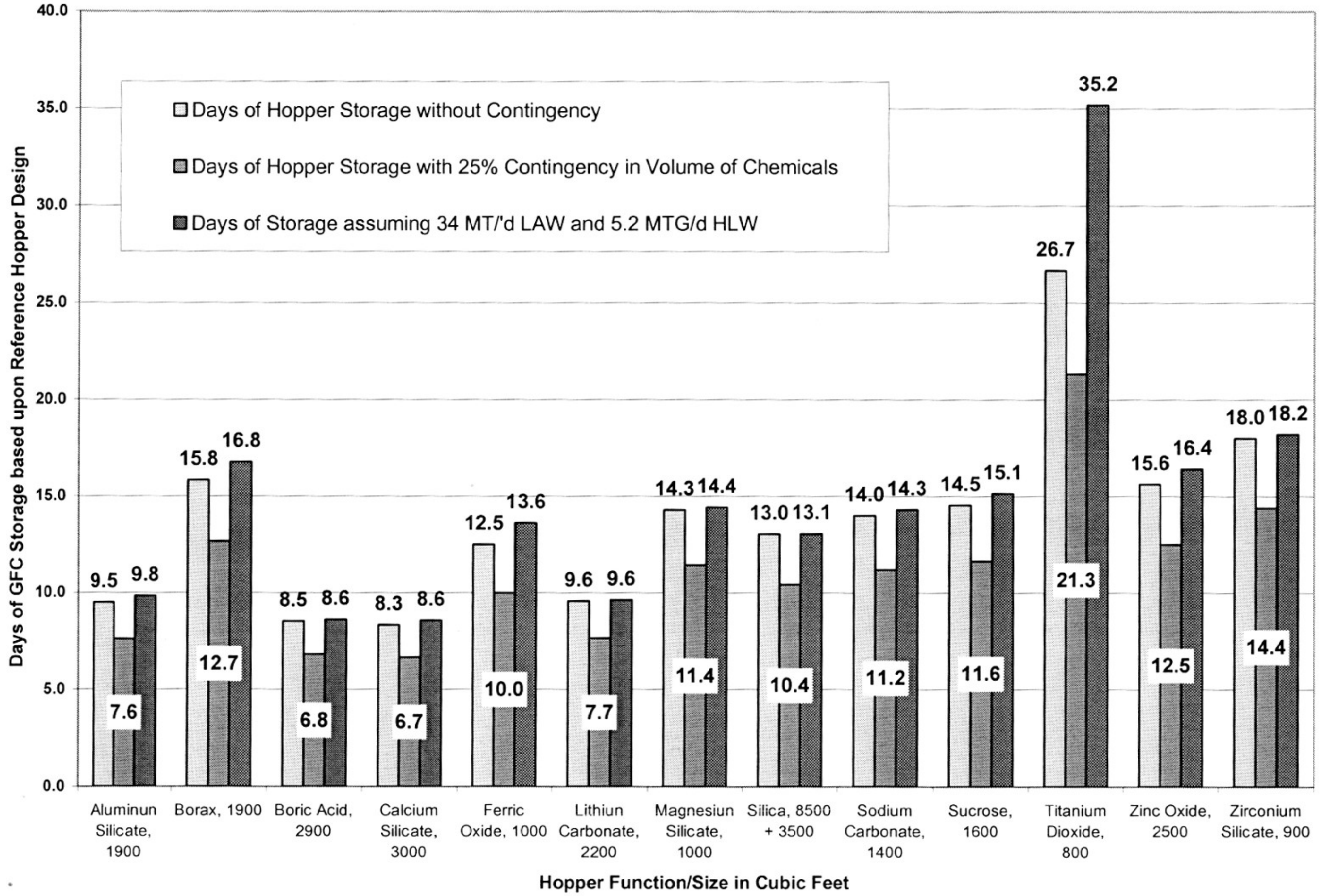

Figure A.3 Comparison of the Operating Day Capacity of the Glass Former Facility Chemical Hoppers Assuming Three Different Scenarios for the Determination of GFC Hopper capacity

AUDIT NOTES
Section B
HLW MELTER SYSTEM

Introduction

The HLW Melter and supporting systems include the melter pouring system and canister level detection system and are identified and described in the following system description:

- HMP- HLW Melter, Pour Spout and Canister Level Detection

The capacity requirements for the HLW melter are specified in the "WTP Basis of Design" (24590-WTP-DB-ENG-01-001) at 3 MTG/d each. The design capacity of the HLW melter is affected by the quality of the HLW feed (discussed in Appendix A, HLW Feed Preparation System), physical design of the melting chamber, glass melting properties and operational limitations of the melter design. These features will not be addressed in this discussion. Based upon the melter design the glass production capacity of the melter is most directly influenced by the:

- Electrode power
- Feed concentration and waste loading
- Melter bubbler design and operating parameters

Electrode Power

Conclusion:

The electrode power requirements for the HLW melters were estimated based upon heat loss calculations and are specified to be in the range 520 to 600 KW for each melter. This electrode power level will support the production of HLW glass at a rate 2.7 to 3.5 MTG/d assuming an expected HLW glass yield of 350 to 400 gram oxide/liter. The power system has a design margin and can accommodate increased power levels up to an estimated 675 KW. This increased power level can support glass production at a rate up to 3.9 to 4.2 MTG/day assuming an expected HLW glass yield of 350 to 400 gram oxide/liter, respectively. There are no obvious limitations in the electrical power distribution system (electrodes, electrode buss bars and electrical conduit between the power transformer and the electrode buss bar).

Discussion:

The basis for the specification for the electrode power system design capacity requirements is provided in 24590-HLW-RPT-E-03-001. The electrode power was specified based upon assumptions used to account for heat loss from the melter and glass production rate. The specification for electrode power established a lower value of 520 KW, with a maximum of 600 KW. The methods used in the determination of the electrode power is summarized below.

$$P = G*S + A + Q$$

Where:

P = Power to electrodes in KW
G= Melter throughput in MTG/d
S= Specific process energy
(= 108 KW-d/MTG at 573 gram glass/liter feed and 131 KW-d/MTG at 325 gram glass/liter feed)
A= Power to heat the air leaving through the melter off-gas system (32 KW)
Q= Conductive heat losses from the melter (165 KW)

Figure B.1 presents HLW glass production as a function of electrode power based upon the equation above. This figure shows the relationship between melter glass production rate, electrode power and the glass yield in the HLW melter feed.

The power supply system being provided for the two electrodes, for each HLW melter, is comprised of two 375 kVA step-down water cooled transformers capable providing 750 kW of power (WTP-E-ABB-2309). Line losses in providing power to the electrodes are estimated by BNI (informal communication with Jeff Pullen on December 7, 2004) to be 75 kW. Thus, it is anticipated that the maximum power available to the melter electrodes is 675 kW.

Figure B.1 also includes specific energy assumptions for four glass yield assumptions (325, 350, 400 and 573 gram oxide/liter of feed). Based upon the discussion provided in *Appendix A, HLW Melter Feed Preparation System,* the feed concentration should be above 350 gram oxide/liter to maintain stable melter operations. Concentrations of the waste feed above 450 to 500 gram oxide/liter may not be achievable when considering the design limitations of the Pretreatment facility ultra filtration system to prepare concentrated HLW solids concentrate.

The expected feed to be delivered to the HLW Vitrification facility will result in a glass concentration of 350 to 400 gram glass/liter of feed. Under these conditions, the melter electrode power system will meet the WTP Basis of Design melter design rate of 3.0 MTG/d and achieve a theoretical glass melting rate up to ~3.5 MTG/d. Increasing the electrode power to 675 KW will allow a theoretical melting rate of ~4.2 MTG/d which is in excess of the ORP stretch goal of 3.75 MTG/d/melter.

Feed Concentration and Waste Loading

Conclusions:

The current conservatism in the melter power system design will be increased at higher waste loadings resulting in a higher glass production rate because less energy is needed to melt a fixed mass of glass.

There is no clear specification from the HLW Vitrification Project or the Pretreatment Project on the quality (solids concentration, composition) of the HLW concentrate produced in the Pretreatment Facility that is necessary to ensure that the HLW melter will meet the WTP Basis of

Design requirements for glass production at 3 MTG/day each. These issues were discussed in *Appendix A HLW Melter Feed Preparation System* and will not be addressed here.

Discussion:

The relationships among ultra filter solids concentration, waste loading and glass yield are presented in Table B.1 based upon WTP Project R&T data for non-radioactive and radioactive feeds. This data shows that as the glass waste loading is increased, the glass yield will be reduced per liter of melter feed. The results in Table B.1 are based upon meeting the WTP Contract waste loading requirements which are based upon

Table B.1 Summary of Tank Waste Composition, Percent Solids and Glass Yield

Tank Waste	Percent Solids Delivered from Pretreatment, wt%	Waste Loading in HLW Glass, wt%	Mass Glass Oxides, gram oxide/liter melter feed	Waste Loading based upon Non-radioactive and Radioactive Waste Testing
C-106/AY-102	14%	20%	478	23.5%/33%
		30%	**340**	
		40%	263	
AZ-101/AZ-102	18%	20%	606	25%/33%-AZ-101
		30%	**438**	24%/34%-AZ-102
		40%	343	
		50%	282	
C-104	16%	20%	543	25% non-Rad only
		30%	389	
		40%	303	
		50%	248	

Notes:
1. The data on tank waste, percent solids, waste loading in the glass correlated to mass of glass oxides is from 24590-WTP-RPT-01-001, dated July 24, 2001.
2. The data on the waste loading based upon the non-radioactive and radioactive glass tests is summarized from 24590-HLW-ES-PR-04-0001.

Specification1, Table TS-1.1 Minimum Component Limits in High-Level Waste Glass. However, ORP's System Plan (ORP-11242, Rev 2.0) is based upon the use of a glass properties model for estimation of the HLW glass waste loading. The glass properties model will have a glass loading that will be ~25% higher than the WTP Contract loading limits. This will have the effect of reducing the required melter feed glass yield. The net impact is that the current conservatism in the melter power system design will be increased at higher waste loadings because less energy is needed to melt a fixed mass of glass. This is illustrated in Figure B.1 by a reduction in the power requirement for an increased glass yield at a fixed glass production rate.

Melter Bubbler Operation

Conclusion

The efficiency of operation of the HLW melter bubblers is critical to achieving the design capacity of the HLW melter. Sufficient testing was completed on the DM-1200 melter, combined with a reasonable approach to extrapolate the testing data for the WTP melter, to justify an early determination that the WTP melter capacity will achieve a glass melting rate of 3 MTG/d. This glass production rate assumes that the WTP melter has a glass surface area of $3.75m^2$ and a glass production rate of 800 $kg/m^2/d$.

Based upon the design of the WTP melter, and analysis completed on the impact of bubbling on glass production rates (24590-101-TSA-W000-0009-162-00001), it is possible to substantially increase the melting rate of the HLW melter. Technical changes to the bubbler operations which were not completely evaluated in the DM-1200 melter testing, because of design limitations, include: bubbler depth, bubble rate and bubbler overlap. Each of these factors can independently be used to increase the glass production rate.

Based upon testing completed in the DM-1200 there appears to be a process trade-off between the bubbler melt rate and solids (glass and feed) entrainment into the melter film cooler and off-gas system. This may require that the film cooler be mechanically cleaned. A prototype of the melter film cooler cleaner was designed for the WTP (24590-101-TSA-W000-0010). However this component was not tested to validate the design concept. BNI plans on testing this film cooler cleaner during the commissioning phase of the HLW Vitrification facility.

Expected HLW Melter Design Capacity

The current design of the WTP melter appears adequate to support a WTP Basis of Design rate of 3 MTG/d per melter based upon the following factors:

- Melter power system design
- Impact of the bubblers on glass production capability
- Feed quality to be delivered to the HLW melter

Potential issues exist with pluggage of the film cooler during future operations in the HLW melter that have not been adequately resolved during R&T testing. During a number of the bubbler tests in the DM-1200, the film cooler was partially plugged with glass particulate made mobile by the sparging of the glass pool. In these experiments the film cooler needed to be cleaned to remove blockage with a rod. Attempts to flush the film cooler were unsuccessful. Cleaning with a rod needed to occur as much a twice per day. The BNI has designed a film cooler reamer for the WTP melter (24590-101-TSA-W000-0010). However the film cooler cleaner was not tested to validate the design concept. BNI plans on testing the film cooler cleaner during the commissioning phase of the HLW Vitrification facility.

Melter glass pour rate

The HLW melter is designed with two pouring chambers, each of which fills a separate canister located on a separate boogie track system. Melter glass discharge rates in the range of 200 to 500 kg/h are needed to allow the glass stream to fall approximately 20 feet to the bottom of an empty canister in the initial canister pour and allow the glass to flow to the periphery of the canister. At 3 MTG/d the average pour rate is 125 kg/hr and at 3.75 MTG/d the average pour rate is 156kg/hr. The change in melter glass level should be limited to less than 1 inch to minimize thermal shock to the glass contact refractory at the slurry to glass melt line. One inch of glass is equivalent to about 230 kg of glass. Based upon this design basis pour parameters are summarized below. The increase in glass production capability will require that the WTP melter decrease the time duration between pours from 1.8 to 1.5 hours.

Glass Discharge Parameter	3 MTG/d Melter	3.75 MTG/d Melter
Glass Production Rate, kg/d	3000	3750
Glass Discharge Rate Maximum 500 kg/hr	500	500
Mass of Glass/Discharge, kg	230	230
Number of Glass Discharges/canister	13.5	13.5
Discharge Time, hr	0.5	0.5
Melter Recovery Time following Glass Pour, hr	1.8	1.5

The canister level detection system which uses infrared measurement of the molten glass level as the primary level detection technology and gamma radiation as a second technique to verify the canister fill level doe not limit the production of glass in the HLW Vitrification facility.

Improvements in Melter Production Rate

There are a number of potential improvements to the design and operation of the melter and melter feed preparation system than can be made to increase the design capacity of the HLW Vitrification facility. These improvements include:

1. Increasing the power level to the melter electrodes
2. Increasing the glass operating temperature
3. Optimize Melter Bubbler Design/Operations-Deeper Bubblers
4. Optimize Melter Bubbler Design/Operations-Increase Bubblers Overlap/Bubbler Area
5. Optimize Melter Bubbler Design/Operations-Increase Bubbler Air Flow Rate
6. Increase Melter Surface Area
7. Increasing the glass yield of the HLW Melter Feed

Each of the potential methods, its basis for consideration, potential glass production rate improvement, major issues, and probability of success is presented in Table B.2. This assessment indicates that the first five of these can be accomplished with no-to-little modifications to the existing design of the HLW melter system. However design development and pre-operational testing is recommended for Items 2 thru 5. The last two items results in a greater design impact and should only be considered if the other approaches are determined to be unsuccessful. Based upon existing technical information, there is a high probability that a combination of the first five approaches can be used to increase the HLW melter production rate from3.0 to 3.75 MTG/d.

References

1. 24590-HLW-3YD-HMP-00001, "System Description for System HMP, High Level Waste Melter, Pour Spout, and Canister Level Detection", May 30, 2003, Bechtel National, Inc., Richland Washington.

2. WTP-E-ABB-2309, "HLW Technical Description, Technical Information HLW Power Supply", Bechtel National, Inc., Richland Washington.
3. 24590-101-TSA-W000-0009-162-00001, Rev 00A, (REP-RPP-069), "Investigation of Glass Bubbling and Increased Production Rate", October 28, 2004, Bechtel National, Inc., Richland Washington.
4. 24590-HLW-RPT-E-03-001, Rev 0, "Electrode Power Requirements for HLW Melter", April 15, 2004, Bechtel National, Inc., Richland Washington.
5. 24590-QL-HC4-W000-00011-04-00271, Rev 00A, "HLW Mass and Energy Balance-HLW D", Bechtel National, Inc., Richland Washington.
6. 24590-WTP-DB-ENG-01-001, Rev 1B, "Basis of Design", June 3, 2004, Bechtel National, Inc., Richland Washington.
7. ORP-11242, Rev 2.0, "River Protection Project System Plan", September 2003, Office of River Protection, Richland Washington.

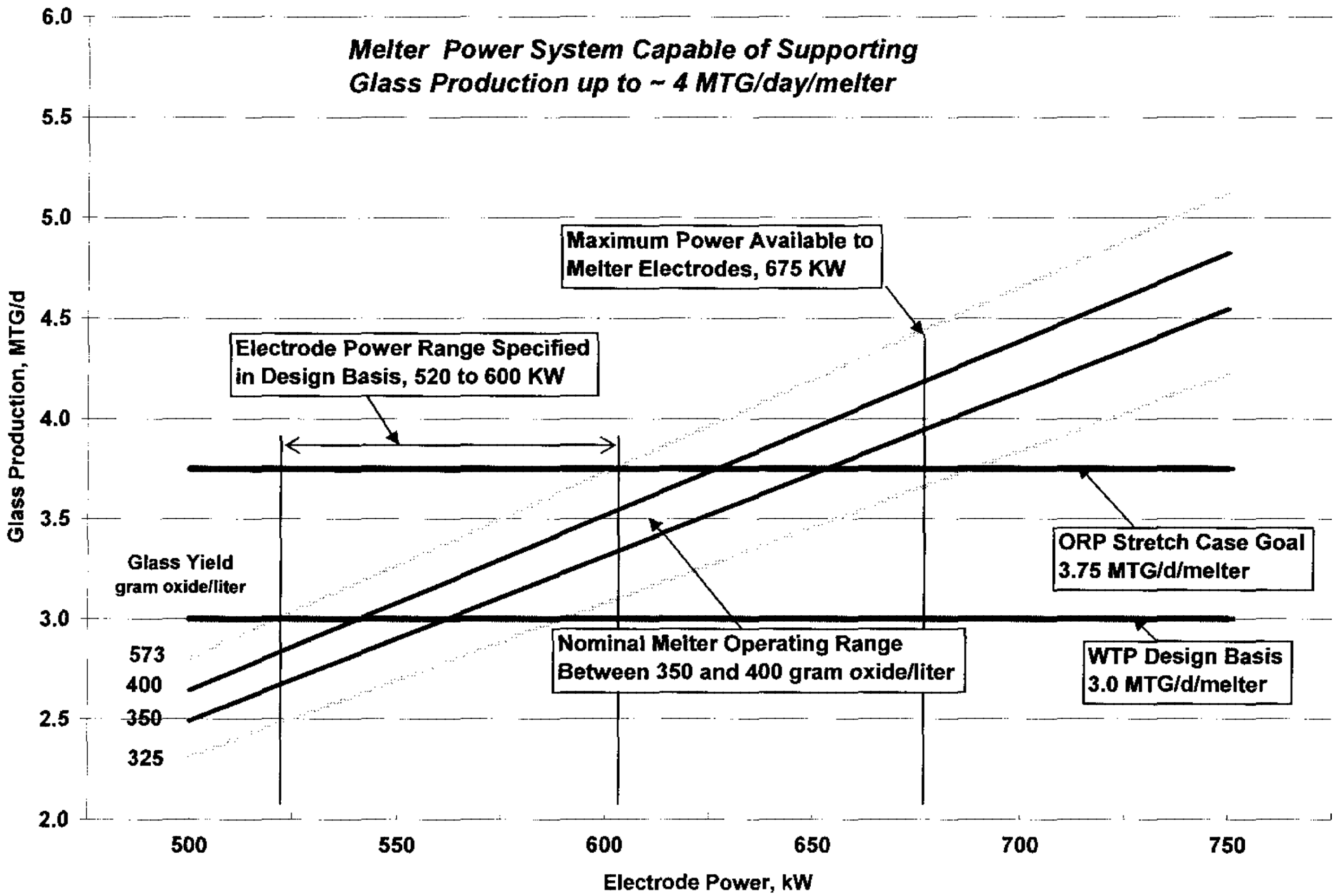

Figure B.1 HLW Glass Production Rate as a Function of Electrode Power

Table B.2 Potential Method to Increase HLW Melter Glass Production Rate

Method	Basis	Potential Glass Production Rate Improvement	Issues	Probability of Success
Increase Power Level to Melter Electrodes	The HLW melter has a power system that is designed for an anticipated melter power range of 520 to 600 KW. These power estimates are believed to be conservative based upon expected heat losses. The electrode power system appears capable of safely operating at power levels up to 675 kW.	Increasing the power level to the electrodes has the potential to increase the melter production rate from 3 to 3.5 MTG/d, to ~4 MTG/d	Increasing the power level can lead to an increase in feed melting (glass production). The impact of the increased feed rate with all other process variables (bubbler rate, feed glass yield, plenum temperature) remaining constant, on melter operation, has not been evaluated.	Medium to High-based upon the design capability of the melter electrode power system.
Increase Glass Melting Temperature	The HLW Melter is designed to operate at a nominal glass melting temperature between 1100°C and 1200°C with a nominal glass operating temperature of 1150°C. Operating the melter at higher temperatures has been shown to increase the glass melter rate. By analogy, testing done on the LAW Pilot Scale Melter(1) showed that increasing the operating temperature of the LAW melter from 1150°C to 1225°C increased the glass production rate from 1.94 to 3.01 $MT/m^2/d$ for an approximate 50% increase in glass production.	Based upon testing results from the DM-3300 Pilot Scale Melter, increasing the glass melting temperature from 1150°C to 1225°C has the potential to increase the glass production rate from 3.0 MTG/d to 4.5 MTG/d	The average melter lifetime will decrease due to accelerated corrosion of the melter electrodes and glass contact refractory shortening the overall melter life. The cost of the HLW melter is small (~$25M) compared to the benefits of the increased glass production rate on reducing RPP life cycle costs. The lifetime of other melter components such as bubblers, dip tube assemblies, etc will also be shortened. Impacts to the glass formulation and melter emission need to be evaluated. The power level to support an increased glass needs to be further evaluated. There may be a small impact on melter cooling systems that should be evaluated.	High-based previous melter testing.
Optimize Melter Bubbler Operation - Deep Bubblers	Testing was completed on the DM-1200 melter with bubbler depths of 19 inch and 25 inch. These test results indicated that the glass production rate	The magnitude of the improvement in glass production rate by placement of the bubblers	The potential benefit of placing the bubblers deeper in the WTP Melter, compared to the DM-1200 test melter has only been estimated and needs to be	High-based upon R&T work completed to date.

Method	Basis	Potential Glass Production Rate Improvement	Issues	Probability of Success
	is increased with a deeper bubbler depth. The WTP melter will have the bubblers approximately 43 inch below the glass surface. This should result in a further increased glass production rate by improving mixing and heat transfer between the bulk glass and cold cap. In addition the bubblers can be operated with higher air flows without significantly impacting additional solids migration (glass splatter) into the off-gas system.	deeper in the HLW melter (when comparing the DM-1200 and WTP Melters) been estimated to be ~25% or equivalent to ~1MTG/d/melter. This observation was essential for the R&T program to project that the WTP Melter is adequate (e.g. support a production of 3.0 MTG/d/melter).	verified in Cold and Hot Commissioning of the WTP Melter.	
Optimize Melter Bubbler Operation - Improve Bubbler Overlap/Bubbler Area	The WTP Melter design was originally designed as an "unbubbled" melter. BNI's proposal for an increased melter system (e.g. changing from 1.5 to 3.0 MTG/d) did not consider an alternative melter/lid design that would optimize melter performance. Testing at VSL/Duratek demonstrated that there is a strong relationship between the glass production rate and specific bubbled area. The specific bubbled area is the area of the bubbles minus overlap divided by the total area.	Testing at VSL/Duratek[3] indicates that it is possible to increase the HLW Glass production rate in portion to the specific bubbled area. For example, an increase in the specific bubbled area from ~0.15 to 0.20 m^2/m^2 will increase the HLW glass production rate from 3.0 MTG/d to 3.75 MTG/d. The limit of this potential improvement is not completely defined.	Redesign of the HLW Melter lid and possibly the HLW bubbler assembly will be required to optimize the Bubbler Overlap and specific bubbled area.	High-based upon the design of the WTP LAW Melter and existing R&T data.
Optimize Melter Bubbler Operation – Increase Bubbler Air Flow Rate	Testing done at VSL/Duratek[3] has shown that there is a direct relationship between the bubbler air flow rate and glass production rate per unit surface area. The increased glass bubbler rate can lead to increased solids/aerosol generation from the melter.	The specific glass production rate is dependent upon the bubbler air rate. Based upon work completed by Duratek[3] it is possible to increase the melter specific production rate from 800 to 1000 kg/m^2-d by increasing the bubbler hole air rate from 0.71 to 1.0 SCFM.	Increasing the bubbler rate can increase the rate at which glass splatter occurs in the melter plenum and glass particulate is carried into the off-gas system. This can be mitigated by: • Operating the bubblers underneath the off-gas/film cooler exit nozzle at lower air rates. • Redesign of the melter lid to optimally locate the bubbler	High-based upon DM-1200 test data and implementation of mitigating measures for glass solids generation.

Method	Basis	Potential Glass Production Rate Improvement	Issues	Probability of Success
		This would yield an increase in WTP melter production rate from 3.0 to 3.75 MTG/d.	assemblies in the melter plenum. • Installing and operating the film cooler operating device.	
Increase Melter Surface Area	The HLW melter production rate is directly dependent upon melter surface area. A limited potential exists to increase the WTP melter surface area by allowing the melter length to be expanded in southern direction from its installed orientation. The WTP melter has an internal melt cavity that is 5 ft wide by 8 ft long (3.75 m^2).	The increase in glass production will be directly proportional to the increase in surface area. For each one foot of increase to the melter length, the melter capacity can be increased by 12.5 % or 0.34 MTG/d.	A longer WTP Melter redesign is possible. However there will costs related to redesign of the melter, melter overpack and some in-cell components. The extent of redesign is related to the objectives for the increase in surface area. An alternative to reduce the glass contact refractory thickness and thereby increasing the internal glass surface area is unlikely due to the modest thickness (12 inch) of the glass contact refractory in the current design.	Medium to High-redesign of the melter and affected support systems (overpack, jumpers, etc.) will be required. No technological risk in redesign.
Increase Glass Yield Concentration of HLW Melter Feed	The glass production rate is directly proportional to the glass yield concentration of the HLW Melter feed. The glass yield concentration is dependent upon two major factors: the waste loading in the glass, and the HLW solids concentration from the Pretreatment facility. See Appendix A for a further discussion.	Increasing the glass yield is an effective method to increase glass production rate. For example, based upon the electrode power sizing calculation(2) and assuming a electrode power level of 600 KW, the glass production rate at 325 gram oxide/liter is 3.1 MTG/d/melter and at 573 gram oxide/liter is 3.7 MTG/d/melter.	The Pretreatment facility is being designed to provide washed and leached solids at a nominal concentration of 20 wt%. These solids are diluted with the addition of Cs concentrate, Sr/TRU precipitate and flush solutions. The extent of dilution of these solids has not been established. In addition, the glass yield must be at least 350 gram oxide/liter to maintain stable melter operations. Unless a concentration process is added to the process flowsheet, (located in a new facility between the Pretreatment and HLW Vitrification Facility) the potential to increase the glass yield of the HLW melter is low.	Low-based upon existing WTP process systems.

Notes:
1. TRR-PLT-081, "Pilot Melter High Temperature Operation Assessment Test Results Report", 2004, Duratek, Columbia, Maryland
2. 24590-HLW-RPT-E-03-001, Rev 0, "Electrode Power Requirements for HLW Melter", April 15, 2004, Bechtel National, Inc., Richland Washington.

Method	Basis	Potential Glass Production Rate Improvement	Issues	Probability of Success
3. 24590-101-TSA-W000-0009-162-00001, Rev 00A, (REP-RPP-069), "Investigation of Glass Bubbling and Increased Production Rate", October 28, 2004, Bechtel National, Inc., Richland Washington.				

AUDIT NOTES
Section C
HIGH-LEVEL WASTE MELTER OFF-GAS TREATMENT SYSTEM

Introduction

The processing vessels and melters, within the High-Level Waste Vitrification facility, all generate gaseous waste streams (i.e., offgas) that must be treated to clean these respective off-gases to constituent levels acceptable for releasing the remaining portion of these offgases back into the environment. In the BNI WTP design, for the vitrification of high-level waste, the melter off-gas treatment system is designated as the HOP system and the process vessel vent system is designated as the PVV system. The offgases from both of these systems are brought together at an intermediate processing point within the processing (HOP) system for the melter offgas. Process condensates and recycle from the HOP and other HLW Vitrification facility systems are collected in the radioactive liquid waste system (RLD) before transfer back to the Pretreatment facility for additional treatment.

This portion of the oversight review focused on the treatment system (HOP system) for the HLW melter offgas and the vessel vent system gases, in relation to consideration of glass production capacity. The primary focus was on consideration of the melter offgas portion of the HOP system, especially in regards to assessment of the HOP system's ability to accommodate an enhanced HLW glass production rate. The HOP system description (24590-HLW-3YD-HOP-00001, Rev 0) was a general source document for review of HOP system components, process function, and other aspects of the design, and for much of the summary description information in this Appendix. The Rev 0, of the system description is recognized by BNI and ORP as outdated regarding certain topics (e.g., secondary off-gas system), so additional effort was made to: 1) obtain and review more detailed and up to date design documentation (e.g., process data sheets, mechanical data sheets, design calculations, design specifications, flowsheet design documents, including the "Design Verification For HLW Melter Off-Gas System (HOP)" (24590-HLW-DVR-M-03-004 Rev 0), etc., and 2) conduct additional interviews with cognizant BNI staff, to support the needs of this review.

Overview of HLW Offgas System

Offgas

The HLW melter off-gases will consist primarily of the following contributions:

- Air from in-leakage into the melter, instrumentation, purges, and melter bubbler operations,
- Water evaporated from the melter feed and cold cap chemical reactions,
- Acid gases (e.g., CO_2 , NO_x , SO_x , HCl, HF, etc.) generated from anion reactions,
- Aerosols from dried melter feed and melter cold-cap reaction solids,
- Semi-volatile chemicals generated from the molten glass pool, and
- Radioactive materials from tank wastes (reprocessed spent nuclear fuels),

Offgas system process air additions to the head-end of the primary off-gas system will be primary composed of air that is added to the film cooler unit to perform its functions (cooling and increasing flow-rate) and process air that is added to the line just downstream of the film cooler to help control melter plenum pressure.

<u>HLW Offgas Systems and Primary Functions</u>

The HOP system provides the following functions to collect and treat melter system off-gases:

- Removes hazardous particulates, aerosols and gases,
- Controls melter plenum pressure (vacuum), and
- Provides a confinement barrier for (hazardous) off-gas.

The PVV system together with the offgas treatment capabilities of the HOP system provides the following functions to collect and treat HLW process vessel system offgases:

- Collects and moves process vessel off-gases to the HOP System for treatment, and
- Provides a confinement barrier to hazardous offgases from the HLW process vessels.

<u>Specific Components and Functions of HLW Offgas System (HOP and PVV Systems)</u>

The processing sequence for melter offgas, and the HOP system in general, is divided into two sets of processing steps/components that are run in series. The two sets of this series are simply called the Primary and the Secondary portions of the HOP System. Their respective major components and primary functions of interest to this review are as follows:

Primary Portion of HOP System:

- Melter Offgas Film Cooler
  - Cool the melter offgas and prevent solids build-up on the film cooler and/or the off-gas piping to the SBS.
  - Assist in controlling melter plenum pressure (nominally a vacuum), during abnormal events.

- Melter Pressure Control Subsystem
  - Control melter plenum pressure via addition of control air into offgas stream after film cooler.
  - Provide alternate pathway for offgas to move from melter to SBS, in case melter plenum becomes over-pressurized.
  - Provide valve control for melter offgas venting into melter cave, if the design pathways for off-gas passage, from the melter to the SBS, are not able to control the melter over-pressurization.
  - Maintain a vacuum in melter plenum when pressure control barrier on SBS or WESP is open for maintenance activities.
  - Prevent inadvertent glass pouring from melter, due to melter plenum over-pressurization.

- Submerged Bed Srubber (SBS)
  - Cool melter off-gas so that downstream treatment units respectively operate within an acceptable temperature range
  - Condense out steam in off-gas
  - Remove entrained aerosols (medium efficiency removal of large particles and low efficiency removal of small particles) and remove acid gases in off-gas
  - Transfer condensate, particulates and wash solutions to SBS Condensate Receiver Vessel for processing through the plants radioactive liquid waste disposal system

- SBS Condensate Receiver Vessel
  - Collect condensate, particulates and wash solutions generated by SBS
  - Collect condensate and wash solutions generated by the WESP
  - Collect condensate and wash solutions generated by the HEME
  - Provide condensate recycle to SBS vessel for suspending solids off the bottom to make transfers to this vessel

- Wet Electrostatic Precipitator (WESP)
  - Remove additional radioactive aerosols to extend life of filter media in downstream treatment units of the off-gas treatment system. (high efficiency removal of large particles and medium/high efficiency removal of small particles).

- High Efficiency Mist Eliminator (HEME)--(Process Vessel Vent System comes into HOP prior to HEME)
  - Provides further removal of particulates to minimize HEPA filter replacement frequency (high efficiency removal of large particles and medium/high efficiency removal of small particles)
  - Protect HEPA filters from liquid droplets
  - Provide back-up to SBS and WESP for aerosol removal
  - Remove entrained particulates from vessel vent offgas stream

- High Efficiency Particulate Air (HEPA) Filter Electric Preheaters
  - Heat HEPA filter inlet air to above dew point of water to avoid water condensation and wetting of HEPA filter, which would increase filter failure risk.

- High Efficiency Particulate Air (HEPA) Filters
  - Perform final radioactive particulate removal before discharging treated melter and vessel vent offgas to secondary portion of offgas treatment system (high efficiency removal of large particles and high efficiency removal of small particles)
  - Protect secondary offgas system from contamination, so that secondary offgas treatment units can be contact maintained

Secondary Portion of HOP System:

- Booster Fan Preheater
  - Recover heat from silver mordenite column exhaust to reduce electrical heat load on catalyst skid electric heater
  - Cool silver mordenite column exhaust to facilitate (sulfur impregnated) activated carbon column operation for mercury removal
  - Provide defense-in-depth to assure that water does not condense in booster extraction fans, to avoid damaging the fans

- Booster Extraction Fans
  - Provide motive force for offgas treatment system
  - Facilitate melter pressure control

- Activated Carbon Column
  - Remove mercury (Hg) from offgas

- Silver Mordenite Column
  - Remove gaseous halogens and their radioactive isotopes (e.g., iodine, fluorine, chlorine) from offgas

- Thermal Catalytic Oxidizer (TCO)
  - Oxidize (destroy) volatile organic compounds in offgas

- Selective Catalytic Reducer (SCR)
  - Reduce (destroy) nitrogen oxides (NO_x) in offgas

- Stack Extraction Fans
  - Provide motive force for overall off-gas treatment system and discharge treated off-gas to atmosphere via a flue routed through HLW exhaust stack
  - Facilitate melter plenum pressure (vacuum) control

Figure C-1 and C-2 provide block diagrams of the processing sequence for the primary and the secondary portions of the current HOP system design for the HLW vitrification facility. These ORP generated diagrams reflect the overall design for the HLW off-gas treatment system and include the design changes made by BNI in the last year or so, to rearrange the sequence of certain (secondary system) treatment units [e.g., the "Activated Carbon Column" (HOB ADBR-00001), which is the trap for mercury, and the "Silver Mordenite Column" (HOP-ABS-00002], which traps out gaseous halides (e.g., Iodine, etc.). As noted earlier in this appendix, the BNI system description (24590-HLW-3YD-HOP-00001, Rev 0, November 2002) is <u>not</u> current with some aspects of the HLW off-gas system design, including the changes noted above for the secondary off-gas portion of the HOP system.

Assessment of HLW Off-gas System Capability –To Support WTP HLW Glass Production at WTP Contract Requirement and ORP Enhanced Production Goal

Between the WTP Contract (DE-AC27-01RV14136) and the "WTP Basis of Design"(BOD) (24590-WTP-DB-ENG-01-00001, Rev 1B) documents, the WTP design requirement for HLW glass production throughput is 3MTG per day, for each of the 2 HLW glass melters, using glass melt agitation (e.g., gas bubblers). Even the existing and outdated system description for the HOP and PVV systems (referenced earlier), describes (Sec. 6.1.1.1, page 20) the HLW offgas system design (i.e., status of design documentation to that time) as indicating that the HLW offgas system would be able to support the HLW glass production goal of 3 MTG/d, per melter.

This review and assessment looked at the current inventory of design related documentation to make a judgment as to whether the proposed HLW off-gas system design can meet the WTP Contract requirement for HLW glass production (i.e., 3MTG/d/melter). A very important factor in the assessment of the HLW off-gas treatment system is the recognition that the WTP Project has had a strong commitment through its R&T program to provide evidence from prototypic scaled testing of the proposed HLW off-gas treatment system, as connected to the DM-1200 scaled HLW glass melter system at the Vitreous State Laboratory (Catholic University, Maryland). Significant engineering effort and resources were devoted to create this prototypic version of the HLW offgas system, and very extensive testing; namely, for all WTP Contract Envelope feeds, etc., have been tested, regarding such off-gas treatment performance. Offgas treatment behavior, including identification of problems, including assessment of potential solutions has been a part of this R&T testing program. WTP engineering receives reporting and briefings from the R&T organization, regarding this off-gas treatment system performance testing data, and this has been one of the more active topical areas regarding data reconciliation. One of the key drivers for such attention on the testing performance of this scaled HLW offgas treatment system is the regulatory permitting requirements that the WTP Project must satisfy in design, constructing and commissioning this HLW system. The individual component discussion sections will discuss significant findings, design improvements, and validation testing, regarding these components of the HLW offgas treatment system.

The enhanced production goal (i.e., the ORP stretch case at 3.75 MTG/d/melter) used in this assessment was derived by ORP and reflects a meaningful and representative example of a system planning case for an accelerated tank waste treatment scenario. This represents a 25% increase in HLW glass throughput per melter. Regarding the HLW vitrification offgas system, such an enhancement in HLW glass production rate will logically result in an increase in the overall offgas quantities coming from the melter system and the process vessel vent system. However, per the WTP design documentation and interviews with BNI staff (e.g., J. Rouse, J. Perez), it's apparent that the overall increase in the HLW offgas will <u>not</u> be as large, as the % increase used for the enhanced HLW glass production rate, and depending on other specifics of melter operation (e.g., melt bubbling rate, etc.), it will likely <u>not</u> be a uniform increase for all constituents of the HLW offgases, and especially for those from the HLW melter system, which is the dominant volumetric and mass contributor to the total offgas stream, as well as, the dominant contributor of hazardous constituents that must be removed by the HLW offgas treatment system. Not surprisingly, this summary assessment revealed that the specifics of the likely constituency and magnitude of the increases in offgas will depend significantly upon the specifics of how the HLW glass production rate increase is achieved, especially if most other melter operating parameters are kept close to the levels used for the current HLW glass production rate (3 MTG/d/melter). Appendices A and B, in this Oversight report discuss, in considerable detail, the specifics of approaches for how to significantly increase (e.g., ~25% or more) the HLW glass production rate, without having to make major modifications to the facility and the melter.

For this offgas system discussion, it is sufficient to note that the affect on the offgas magnitude (volume, mass..) and constituency would be bracketed by two general methods for achieving a higher production rate; namely, one that includes using a higher solids concentration in the melter feed, and the would be one that relies more on using a faster feeding rate for the melter. The first approach would likely result in a melter offgas flowrate that would be about the same as for the current baseline HLW glass production rate of 3MTG/d. This is because the flow-rate of steam coming off the melter would be about the same as for the current design (3 MTG/d/melter), and depending somewhat on process air increases, for say a higher flow-rate for the melt bubblers, the overall flow-rate for the HLW offgas would likely not increase significantly. However, it could potentially result in significantly raising the concentration of particulates entrained in the primary offgas exiting the melter, and particularly so, if this approach also involved increasing the flow-rate through the melt bubblers. Given the postulated nature of such changes in the offgas stream exiting the melter, it seems likely that the principal burden on the offgas treatment system would likely be on the primary offgas treatment components, which must deal with the particulates and aerosols in the offgas. The impact on at least some parts of the secondary offgas system could be as high as the fractional increase in feed concentration. The assessment of such impacts, and the ability of each component of the offgas treatment system (i.e., primary and secondary portions of the overall system) to handle such increases in offgas loading will be discussed in the follow-on subsections of this Appendix. For the second approach, where the assumption is that there is a dependence on increasing the rate of putting feed into the melter, the impact on the offgas could be a significant increase in both the flow-rate of primary offgas exiting the melter, as well as, a significant increase in the entrained particulates in the offgas. Depending on how may other melter operations parameters remain unchanged. This second approach could lead to increased burdens, on both the primary and the secondary portions of the HLW offgas treatment system, approximately proportional to the increase in the feed rate to the melter.

The following discussion presents a summary overview of a component-by-component assessment, of the HLW melter offgas treatment system, to determine whether current design documentation provides sufficient evidence that the HLW melter offgas system is indeed being designed to meet this design goal of 3MTG/d/melter. Each of these discussions also includes a summary assessment on whether the given component design appears to have sufficient design margin to support the needs of a significantly enhanced production rate for HLW glass production (e.g., ~25%). (*Note: Quoted text is from the HLW system description, for the HOP and PVV systems, and from Section 6, unless otherwise noted.)*

ORP Assessment –Primary Stage of HLW Offgas Treatment System

Offgas Film Cooler

The primary offgas leaves the melter plenum space through an exit port in the top of the melter, near one corner, and then connects to a cooling unit that sits on top of the melter. This unit is called the offgas film cooler (HOP-FCLR-00001), and functionally its job is to both rapidly cool the offgas stream and to also accelerate its flow-rate. It does these two important functions via a relatively simple pipe-within-pipe type construction, which involves numerous tailored pathways through the inner pipe, so as to bring together the primary offgas stream and process air. The offgas is cooled substantially (e.g., *"from its (melter) plenum temperature of about 750°F to a film cooler discharge temperature of about 510°F"*). An important objective associated with rapidly cooling the primary offgas stream is to quickly reduce the offgas temperature to below temperatures where offgas particulates are still prone to sticking together and/or onto cooler surfaces (e.g., the inner walls of the film cooler walls, off-gas piping, etc.). For the sake of melter plenum pressure control and offgas system functionality it is important to reduce the opportunities for reducing or even shutting-off the throughput capability of the offgas line and/or treatment components. Process air is injected into the film cooler to help accelerate the off-gas flow-rate, and this helps ... *"minimize solids build-up within the film cooler* (Larson 1989)."

Even with the aid of process air injection, the film cooler can still, under certain circumstances, be challenged by agglomeration and build-up of solids deposited on the piping surfaces. To address the functional need to keep the film cooler passageways open, there is : 1) the ability to inject some water into the inlet process air to aid in keeping open the smaller passage-ways in the inner pipe, and 2) to address more aggressive types of solids build-up (i.e., constricting the inner cross-section available for gas flow) there is a service port that provides access for a mechanical-type cleaning tool (e.g., blade, brush, etc.).

The experience at WVDP and the DWPF, as well as, the WTP melter/feed/glass testing development testing program (i.e., WTP Research and Testing group) has reinforced the design effort for the proposed film cooler unit. The WTP scaled HLW melter testing, which includes a close to prototypic offgas system, has shown some tendencies for solids accumulation, and the WTP has designed a mechanical cleaning device, but not tested it.
One mitigating factor with the actual WTP melter will be the fact that the offgas exit (and film-cooler) position will be much further away from the location of the glass melt bubbler units, and this should, on a relative basis, reduce the level of solids entrainment and contribution to clogging deposits witnessed in the WTP HLW scaled melter testing, under certain operating conditions (e.g., high bubbling rates for high glass melting throughput rates, etc.).

Ability to Support WTP Contract Goal for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The film cooler has sufficient design capacity to support melter operations at 3 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The review indicates that the proposed WTP off-gas film cooler unit design should be readily capable of supporting the WTP Contract goal (3MTG/d/melter) for HLW glass throughput. The design documentation indicates that this design is strongly supported by scale testing work (WTP R&T, PNNL, etc.) and analogous HLW glass production experience at other EM HLW vitrification facilities (WVDP and DWPF). WTP cold testing and hot operations experience will determine the specifics of servicing needs for keeping the film cooler appropriately free of solid deposits.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate

Conclusion:

The film cooler has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The simplicity of the WTP film cooler design and its relatively modest needs for basic operational support (e.g., process air injection, etc.) make it very likely that this design can support an enhanced HLW glass production rate. The most problematic consideration that will have to be faced is whether the increased glass production rate includes any significant increase in the tendency for solids to locally deposit in passage-ways with in this device. Increasing flow-rate of off-gas (i.e., whether from increasing feed rate and bubbling rate, etc., as part of increasing glass throughput-rate) should not significantly degrade the film-cooler performance, and would likely help mitigate the tendency for solids deposition. If the increased through-put significantly increased the concentration of entrained particles then this might impact film-cooler performance, or at least operational servicing requirements, but both aspects of performance should remain well within acceptable margins.

Melter Off-gas Lines

The primary off-gas line (jumper) (HMP-JMPP-00015 ; -0001x) leads from the film cooler, which is located near a corner of the melter top (rectangular profile) and on to the submerged bed scrubber (SBS) (i.e., for removal of steam and large particle of solids). This primary offgas line is sized to accommodate intermittent off-gas surges, which are defined as ... *"the ratio of the maximum rate of steam and noncondensable gas generation to the average rate"*..of generation. To further ensure sufficient design capacity for handling melter off-gas surges (and desired range of melter plenum pressure—i.e. vacuum), the offgas system design includes an additional offgas transfer line, coming off the top of the melter and leading to the SBS unit. This line is called the "stand-by" (or sometimes just an "alternate") offgas line, and exits the top of the melter without going through a film cooler. The line is ... *"sized for 100% of the normal off-gas flow"*.. (rate) from the melter, and is actuated into service via a pressure control valve, so as to help control the melter plenum pressure, and is protected from clogging near its inlet, when not in service, by an air flush stream.

By-pass events were reviewed, regarding the BNI design, and references included the off-gas system description cited earlier, the PSAR and "Description of HLW Vitrification System Bypass Events" (24590-HLW-PER-PR-03-001 Rev A ; DWP-010). If both the melter's primary and stand-by off-gas lines are not able to handle (i.e., in combination) either a large surge in melter off-gas, or somehow limited in their capacity for handling the melter exit needs for off-gas flow-rate, the design includes on other off-gas exit pathway. Namely, the melter design includes a pressure actuated valve that will open in the case of melter pressure emergencies and just vent the primary offgas directly from the melter to the melter cell. The C5 ventilation system would then have to deal with such input, at least until the melter offgas system can be stabilized (e.g., melter plenum pressure reduced, off-gas emissions lowered and either the primary or stand-by offgas lines brought back into service to handle the offgas exit flow-rate needs. It should be noted that the HLW Project is struggling somewhat at present with coming up with a satisfactory design, including fabrication/installation details, for the C5 piping and the filter housing located in the HEPA filter cave. The situation is presenting considerable design challenges because of the very limited space available, to support the fabrication and installation. These design challenges are worth noting here because they are being driven in part by the predicted response of the respective candidate design options to the type of design basis event (DBE) that could lead to activating this third pathway for removing offgas from the melter (i.e., during a offgas surge event requiring action to maintain melter plenum pressure within an acceptable upper limit).

The design records indicate that the HLW off-gas lines (i.e., the primary line and the stand-by line) from the melter to the SBS treatment unit are conservatively designed so as to provide ample capacity (flow-rate, etc.) to help maintain the melter plenum pressure within acceptable levels (i.e., a modest vacuum). The limiting case for such design is that for the … *"limiting steam evolution rate in the melter"*...which is…. *"bounded by film boiling over the entire melt surface." "This can yield a surge of about 20 times the average steam flow rate during 3MTG/d production. The main and stand-by off-gas lines are sized to maintain melter plenum pressure in a negative condition for this magnitude of steam flow (24590-HLW-PYC-HOP-00002)."* The design work has been supported by WTP HLW scaled melter testing, which included a close to prototypic off-gas treatment system. There was some evidence found in the WTP testing of solids deposits accumulating at a high-point within the primary off-gas line from the melter to the SBS unit. A key feature of the off-gas lines from the melter to the SBS unit is that they are segmented and can be taken apart for servicing if a serious clogging problem were to ever result.

Ability to Support WTP Contract Goal for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The melter offgas line has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The review indicates the proposed WTP offgas piping design, especially for the link between the melter/film-cooler to the SBS unit, should be readily capable of supporting the WTP Contract goal (3MTG/d/melter) for HLW glass throughput. The design documentation indicates that this design is strongly supported by vitrification and off-gas system scale testing work (WTP R&T, PNNL testing, etc.) and analogous HLW glass production experience at other EM HLW vitrification facilities (WVDP and DWPF). WTP cold testing and hot operations experience will determine the specifics of any servicing needs for keeping the offgas lines from the melter to the SBS unit appropriately free of solid deposits.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The melter offgas line has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The simplicity of the WTP off-gas line (jumper), from the melter to the SBS unit, makes it very likely that this design can support an enhanced HLW glass production rate. The most problematic consideration that will have to be faced is whether the increased glass production rate includes any significant increase in the tendency for solids to locally deposit in this piping. If the offgas flow-rate were to increase (i.e., whether from increasing feed rate and bubbling rate, etc., as part of increasing glass throughput-rate), this should not significantly degrade the piping performance, and might even help mitigate any tendency for solids deposition. If the increased through-put significantly increased the concentration of entrained particles, then this might impact performance of this offgas line, or at least operational servicing requirements, but both aspects of performance should remain well within acceptable margins.

Submerged Bed Scrubber (SBS)

The SBS unit (HOP-SCB-00001/00002) (one per each primary off-gas treatment system, with one such system per each melter), is described as a … *"semi-passive co-current aqueous packed ..(ceramic balls)..scrubbing column."* …that scrubs … *"entrained radioactive particulate ..(and other solids) ..from the melter offgas, and is also .. "serves to cool and condense the melter vapor emissions"* (24590-HLW-MKD-HOP-00016, Rev 3).

The SBS unit is being designed for the life of the plant (i.e.,40 yr lifetime), but it is serviceable for maintenance, including some of its internals, and some of its internals are designed to be removable during plant service, if needed [e.g., the *"internal bed or column"* is to be *"removable"*, as noted in Mechanical System Data Sheet (SBS) (24590-HLW-MKD-HOP-00016, Rev 3)]. The same reference notes that *"Non-routine maintenance is expected to occur annually."* Beyond such nominal maintenance expectations is a design recognition that the whole SBS unit could be replaced, if it was ever necessary (Discussion with J. Rouse/BNI).

The melter offgas stream comes into the unit from the top and is delivered down below the bottom (perforated) plate of the enclosure column, which suspends a passive scrubber bed of ceramic balls, well above the bottom of the vessel. The interior of the vessel is filled with water (scrubber solution) to several inches above the top of the scrubber bed. There are two separate inlet/delivery pipes down into the SBS unit, one for primary offgas line and one for stand-by offgas line, from the melter. A columnar set of cooling coils are located out near the interior surface of the rounded bottom columnar vessel, and they extract heat from the resultant offgas and scrubber solution interaction. The incoming melter offgas is rapidly quenched by the SBS aqueous scrubber solution. Particulates, especially the larger ones entrained in the offgas, are removed via the scrubber bed and carried in the scrubber solution and deposited in the lower region of the vessel, where they and a fraction of the condensate is moved periodically to the SBS Condensate Receiver Vessel (HOP-VSL-00903/00904). The particulate decontamination factor (amount of component in / amount of component out) is usually from 5 to 15." The process data sheet lists the *"removal efficiency at >97% at 0.35 micrometer"* ...particles sizes and above. The SBS is designed to take melter offgas (nominally "394°F"during melter feeding...or .."752°F"..when melter idled) and cool it (nominally to.. "122°F") (24590-HLW-MKD-HOP-00016 Rev 3). This same reference lists the calculated combined "design cooling duty" for the SBS vessel as ..1,926,000 BTU/hr and a calculated nominal duty need of 993,000 BTU/hr and a calculated maximum duty need of 1,530,000 BTU/hr." This indicates a margin above nominal capacity of ~54%. The nominal range of operations is 120°F to 140°F, and the preceding reference explains that the 140°F value may possibly occur when .. *"Occasional process upsets will direct undiluted offgas to the SBS at temperatures near 1250°F, where the SBS will cool the gases to 140°F."* The Mechanical System Data Sheet (SBS) (24590-HLW-MKD-HOP-00016 Rev 3) note that the unit can reach 212°F during "operating fluctuations." The Process Data Sheet (SBS) (24590-MKD-HOP-00006, Rev 1) lists the "maximum inlet..(melter) ..offgas temperature ...as 924°F per calculation 24590-HLW-PYC-HOP-00003 Rev A." An example, from the earlier component description sections, would be if the primary offline or film cooler became clogged and the stand-by line was activated. Even with this considerable range of inlet offgas temperature extremes, at least during process upset intervals, the SBS is robustly designed in terms of cooling capacity, to rapidly cool the inlet gases down to within the much lower temperature range noted above. The HOP Booster Fans (downstream of the HEPA filters) keep the SBS unit, as with other primary offgas units, nominally operating below atmospheric pressure. The nominal operating pressure range for the SBS vessel is listed as between a *"minimum of -160 inches (water gauge) and a minimum of 0 inches (water gauge)"*... in the Process Data Sheet (SBS) (24590-HLW-MKD-HOP-00006, Rev 1).

Three of the four main functions of the HLW primary offgas SBS unit (i.e., cool melter offgas; condense offgas/steam; remove aerosols; and transfer out of condensate,particles and wash solutions are primarily dependent upon the ability of the SBS unit to extract heat, at sufficiently high rates, from the resultant solution mixing of the offgas stream and scrubber/condensate solution. Hence, establishing an SBS unit to provide sufficient processing capability is primarily dependent upon sizing of the vessel and its interior components to: 1) handle an appropriate HLW melter offgas flow-rate range and 2) to provide sufficient cooling capacity (i.e., both the interior cooling coils and the cooling jacket on the vessel exterior) to condense out the steam, and other condensibles in the in-coming offgas, as well as, achieve resultant temperatures and flow-rates that support scrubbing out the particulates. The fourth major function is that of transferring condensibles and particularly particulates to the SBS Condensate Receiver Vessel, which then returns condensate solution back to the SBS unit so as to help maintain the desired level of aqueous scrubber solution in the SBS unit (i.e., to a level a few inches above the top of the scrubber column).

During this assessment several types of design related documents, concerning the SBS unit and the incoming and out going character of the primary off-gas stream, were reviewed, to help assess the sufficiency of the proposed HLW SBS design to: 1) support the WTP Contract requirement of 3MTG/d/melter, and 2) to assess the extent of the SBS design margin and the ability of the SBS design to support an enhanced HLW glass through put rate. Besides the system description document, process data sheets, and mechanical data sheets that were referenced above, this review also looked in detail at the following documents:

- "HLW Submerged Bed Scrubber Cooling Jacket Effectiveness" (24590-HLW –MEC-HOP-00008 Rev B),
- "HLW Submerged Bed Scrubber Cooling Jacket Coils Effectiveness" 24590-HLW-MEC-HOP-00009 Rev B), 3) "Design of Cooling Jacket for HLW SBS Column Vessel" (24590-HLW-MEC-HOP-00011 Rev A),
- "Sizing of the HLW Submerged Bed Scrubber Column and Vessel" (24590-HLW-MKC-HOP-00003 Rev B)
- 5)"HLW SBS Condensate Receiver Vessel Sizing" (24590-HLW-M6C-HOP-00005 Rev A), and
- 6)"HLW Vitrification Facility Feed and Effluent Design Basis Flowsheets" (24590-HLW-M4C-30-00003 Rev B).

The summary assessment results are as follows:

<u>Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate (3MTG/d/melter)</u>

<u>Conclusion</u>:

The SBS has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

<u>Discussion</u>

The BNI design documentation indicates an SBS design margin of about 25% or more for comparisons between assumed design need and designed capability of the SBS unit, relative to several key parameters , including cooling capacity, gas flow rates, etc., per specified operating conditions. The review indicates the proposed WTP SBS unit should be readily capable of supporting the WTP Contract requirement (3MTG/d/melter) for HLW glass throughput. The design documentation indicates that this design is strongly supported by scale testing work (WTP R&T, PNNL early development, etc.). The SBS unit was one of the components in the WTP R&T vitrification scaled testing, including a prototypic off-gas treatment system, which went through extensive testing, problem identification with the test unit and its design, discussions with BNI WTP designers to improve the WTP SBS unit design and also recognition that certain performance problems found with the SBS scaled testing system were particularly troublesome when the decision to use bubblers was made. It was recognized that WTP SBS unit design had evolved to be significantly different from that of the design for the scaled testing system SBS unit. A decision was made to build and test a new SBS unit that was prototypic of the current WTP SBS unit design. This unit was tested during FY-03 and FY-04 and found to work very well and to have eliminated the previous problems (e.g., rapid clogging restriction of the downcomer pipe, near the elevation of the bottom support plate for the scrubber bed).

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The SBS has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

There is extensive design documentation and testing documentation and evidence of data reconciliation between the design and the testing work to indicated that the proposed WTP SBS unit likely has a substantial margin in the capability (i.e., at least about +25%). Given this and this review assessment regarding the likely impacts of an enhanced HLW glass throughput upon the primary off-gas character (e.g., flow-rate, relative concentrations of constituents, etc.), for a bounding range of approaches for achieving the enhanced glass throughput rate, leads to the conclusion that it is likely that there is ample design margin in the WTP SBS unit to support such an enhanced HLW glass throughput. Certain operating parameters could be modified to help accommodate an enhanced HLW glass throughput goal. Parameters such as the SBS scrubber solution operating temperature could be raised some, to help accommodate increased offgas flow-rate and/or loading of steam in the offgas stream, and increasing the flushing cycles, etc., and delivery to the SBS condensate receiver vessel could be also done in the effort to help accommodate the enhanced throughput rate of the SBS unit.

Wet Electrostatic Precipitator (WESP)

Like the SBS unit there is one WESP unit per each primary off-gas treatment system for each HLW melter system. The WESP unit (HOP-WESP-00001/00002) has the primary functions of further removing particulates (i.e., smaller than the sizes already removed in the SBS unit and on down to submicron sizes) and to remove much more of the aerosols from the primary off-gas stream. The WESP is relatively large vertically oriented columnar-like unit (~24+ft high by ~6ft across), in which the primary off-gas stream coming from the SBS treatment unit is further treated by the WESP in a single pass-through process. This incoming stream of primary off-gas enters the WESP unit near the bottom and moves upward through a mid-section that distributes the flow through some ~8 dozen vertically aligned metal tubes that provide the pathway through this treatment section of the device (24590-QL-POA-MKEO-00001-14-01, Revision 008). Each of these metal tubes has a electrode (ribbon-type) down the tube's axial centerline, and this (negative) electrode is highly energized during treatment operations and results in aerosols and small particulates becoming electrically charged (i.e., a corona effect) and subsequently deposited out on the inner wall surface of each of these tubes (positive electrode). The Process Data Sheet (WESP) (24590-HLW-MKD-HOP-00002 Rev 2) notes that, for removing particles and droplets equal or greater than 0.35 micrometers in diameter, the goal is greater than 97%. The off-gas coming into the WESP is moistened slightly upon arrival, to help condition the solids, and then a water spray nozzles system, located at the top of the tube bundle, is used to periodically wash the collected deposits off the inner wall surface of the tubes. The earlier conditioning step (water-misting) helps the entrained solids to stay moist, less consolidated as deposited on the tube wall, and thus easier to remove during the water spraying. The wash down liquids and solids mixture drains into the bottom of the WESP and continues on down to its ultimate collection point, which is the SBS Condensate Receiver Vessel (HOP-VSL – 00903/00904). To accomplish more aggressive cleaning of the tube walls, there is the capability to occasionally backfill the WESP with a nitric acid (water) solution to do a soaking operation, to help remove deposits on the tube walls and wall surfaces of the lower section of the WESP unit. The nominal operating pressure range for the SBS vessel is listed as between a.. *"minimum of -160 inches (water gauge) and a minimum of 0 inches (water gauge)"*... in the Process Data Sheet (WESP) (24590-HLW-MKD-HOP-00002, Rev 2).

Except for certain aspects of the electrical service, the rest of the WESP, which is relatively simple mechanically, is being designed to provide treatment service for HLW primary offgas during the lifetime of plant unit (i.e., 40 yr life). Unlike the SBS, the WESP vessel cannot be replaced, and is welded unit housed in within the HLW facility in a room that is considered to be a limited access location with no intended service capabilities. The very limited portion of the WESP that is designed for service maintenance, including some parts replacement, is the electrical power leads to the unit and the electrode connections to those power leads. The power supply system for the WESP is fully serviceable and even replaceable and is located in a room above the one containing the WESP vessel. The individual tube electrodes of the WESP cannot be replaced or individually serviced. One engineering issue, regarding WESP fabrication, which ORP and BNI are still interfacing on, is the extent to which the welds of key components of the WESP (e.g., the tube bundle welds, gas distribution system, WESP vessel, etc.) will be volumetrically inspected after welding. Although the unit is relatively simple in design and overall functionality, it is still processing corrosive solutions, and must perform for life of the plant. The WESP is a treatment unit covered by the regulatory permitting (air quality, etc.) for the HLW facility, and if a WESP unit were to fail completely, the operation of that given melter system would apparently have to ultimately stop production, if a satisfactory work-around solution could not be found to successfully modify the dangerous wastes permit for the WTP. J. Rouse/BNI, the offgas system designer indicated that there may be enough treatment capacity in the HEME units that are down stream of the WESP unit, to enable the HLW primary off-gas system to operate satisfactorily without a WESP unit. However, this would probably necessitate running the downstream HEME units in series; whereas, the WTP design has the HLW primary off-gas system set up with the HEME units in parallel, with only one unit operating at a time (i.e., the other would be down for servicing and then in stand-by). Any such changes, if workable would also have to be addressed by a modification to the dangerous waste permit.

This assessment of the WESP design, regarding its ability to meet the needs of the WTP Contract requirement of HLW glass production (3MTG/d), as well as, assessment of possible design margin that might support an ORP desired enhanced rate of HLW glass production, involved reviewing a series of WESP design related documents, and supporting discussions with BNI staff (e.g., J. Rouse/Engineering, J. Perez/R&T). These included the mechanical data sheets, process data sheets, which were cited earlier in this discussion and the engineering specification (WESP) for final design and procurement (24590-WTP-3PS-MKEO-T0001 Rev 4). J. Perez provided perspective on the extent of WESP development issues identified during WTP (R&T) testing (HLW vitrification scaled testing (e.g., DM-1200 system with prototypic WTP treatment design for HLW off-gas). It was apparent that there has been considerable interaction between R&T and Engineering, regarding the WESP design, especially corrosion issues regarding the electrode connections to the power leads and means to mitigate such performance issues, for a proposed life-of-plant unit.

Ability to Support WTP Contract Goal for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The WESP has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The review indicates the proposed WTP WESP unit should be readily capable of supporting the WTP Contract requirement (3MTG/d/melter) for HLW glass throughput. The BNI design documentation indicates a WESP unit design margin of about 25% or more for comparisons between assumed design need and designed capability (calcs., etc.) for flow-rate etc.. The design documentation indicates that this design is strongly supported by vitrification and offgas scale testing work (WTP R&T, PNNL, etc.). The WESP, like the SBS unit, was one of the components of the WTP R&T vitrification and off-gas system scaled testing that went through extensive testing, problem identification with the test unit and its design, discussions with BNI WTP designers to improve the proposed WTP HLW WESP unit design.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The WESP has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The available design documentation and testing documentation and evidence of data reconciliation between the design and the testing work indicates that the proposed WTP WESP unit likely has a margin in certain key capability (e.g., at least about +25%) to support the ORP proposed stretch case for HLW glass production. Given this and this review assessment regarding the likely impacts of an enhanced HLW glass throughput upon the primary offgas character (e.g., flow-rate, relative concentrations of constituents, etc.), for a bounding range of approaches for achieving the enhanced glass throughput rate, leads to the conclusion that it is likely that there is ample WESP unit design margin to support such an enhanced HLW glass throughput. Some impact on the operations cycle of the SBS Condensate Receiver Vessel might occur, but the WESP, except during the occasional backfill/acid soak, does not normally contribute a large volume of process solution to this vessel.

High Efficiency Mist Eliminator (HEME)

As noted the principal functions of the HEME treatment unit, in the primary stage of the HLW offgas treatment system, is to further condition the melter offgas, along with the incoming (much smaller) offgas stream from the PVV system. The HEME unit treats the incoming offgas mixture by removing more of the entrained radioactive aerosols and fine particulates that are in the incoming gas mixture (i.e., for the melter offgas portion of this mixture, the HEME unit is just another in a series of treatment units –SBS, WESP-- that have taken out selective portions of such contaminant types within the melter offgas stream). Process Vessel Vent (PVV) System offgas is added into the HLW melter offgas stream at this point (i.e., before the HEME, in the primary stage of the HLW offgas treatment system. The PVV system brings an offgas mixture dominated by process air, from ventilation of various process vessels

The resultant HLW offgas stream mixture (i.e., melter offgas and PVV offgas), coming into the HEME unit, contains enough moisture, fine aerosols and fine particulates that such that this contamination burden needs to be further reduced before the offgas mixture is put through the HEPA filters, which are the next treatment stage in the primary offgas system). The HEME unit is described as .. " *medium efficiency wet filter that has a minimum aerosol removal efficiency of approximately 99% for aerosols less than one micron.* " The incoming offgas enters the unit near the bottom, is conditioned with misted water addition, and then passes up through a bundled set of cylindrical filter column, where ... " *the liquid droplets and other aerosols in the offgas interact and adhere to the filaments by surface tension* ", the offgas exits out the top of the unit. These filter deposits of liquid and fine particulates agglomerate as they build up on the filters and eventually much of these deposits flow by gravity to the bottom of the unit and drain on down to the SBS Condensate Receiver Vessel (HOP-VSL-00903/00904) for collection and eventual transfer back to the Pretreatment Facility as a recycle stream. A portion of the off-gas deposits on the HEME filters do not drain off, and such deposits will build up and result in sufficient pressure drop across the filters that maintenance is needed to clean off such deposits, to maintain the off-gas system and the HEME unit within desired operational parameter ranges. Per the HEME design, the range of maintenance operations, even includes a capability, if needed, to occasionally backfill the HEME unit with a nitric acid solution and perform soak and washdown operation. The primary stage of HLW offgas treatment system has two HEME units that are installed in a parallel line arrangement, so that when one HEME unit is treating incoming offgas, the other HEME unit is shutdown for filter service maintenance and stand-by duty.

Review of the design documentation for the HEME unit, and especially the BNI calculation document "Process Design of HLW Offgas High Efficiency Mist Eliminator" (24590-HLW – MKC-HOP-00011), along with the mechanical data sheet (HEME) (24590-HLW-MVD-HOP-P0007 Rev 0 ; DWP015) revealed evidence that the WTP HEME unit design is based on a robust combination of prior process design and development work for this type of device. This includes early development and design work (PNNL), subsequent design and production experience at the

WVDP facility, work at the SRS site by WSRC, and a BNI process design approach that will yield a HEME unit that will operate conservatively within range of bounding parameter values that support the filtering phenomenology taking place in the HEME unit. This calculation document notes.. *"Brownian diffusion mode of particulate collection is the most efficient capture mode"* for such filtering, and the proposed design selected a key filter parameter value (18fpm) (i.e., for "face velocity" - total flow volume entering the unit divided by filter surface area—normal to the flow direction) that is about ½ the upper limit (40 fpm) for face velocity range for such Brownian behavior. Conservative data input appear to have been consistently used in the design. To maintain system compatibility with the downstream booster fans, which are the primary providers of the desired range of pressure drop across the primary off-gas treatment stage, minimum, nominal, and maximum pressure drops across the HEME unit were selected (i.e., 2, 5 and 20 inches of water gauge - see 24590-M4C-HOP-00011, pgs 18, 19, 20). Flow-rates (ACFM) corresponding to these pressure drops, along with the face velocity were used to determine the "required" filter surface area of the HEME filter elements, to which a 20% contingency was added. The number of filter units and the desired wash down water flow-rate were also conservatively determined (e.g., .. *"for operating flexibility, the maximum flow is set at 100 gph"*.while the nominal flow needed was estimated to be 40 gph). Experience for WTP R&T testing at VSL, and production experience at WVDP and DWPF, and the proposed WTP primary off-gas treatment system the HEME filter washdown is estimated to be needed only about *"twice per year."* The filters can be changed out when needed, and such action will then create a solid waste stream that must be accommodated by the WTP design.

<u>Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate (3MTG/d/melter)</u>

<u>Conclusion</u>:

The HEME's have sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

<u>Discussion:</u>

The BNI design documentation, and the relatively robust history of HEME unit design development and usage in vitrification testing systems, including the WTP R&T HLW scaled testing (DM-1200), and the other EM vitrification plant (WVDP and DWPF), provide ample evidence of extensive data base support to BNI design decisions, in combination with considerable conservatism that BNI appears to have incorporated into the proposed design of the HEME unit.

<u>Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate</u>:

<u>Conclusion</u>:

The WESP has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

As noted above there is ample evidence of considerable BNI conservatism having been incorporated into the proposed HEME design, and this should provide ample margin to enable this particular treatment unit of the HLW primary offgas stream to support the ORP stretch case increase in HLW glass production rate.

HEPA Preheater and HEPA Filters

The electric preheater unit (HOP-HTR-00002A/1B) conditions the incoming HLW offgas (from the HEME unit) to raise its temperature above the dew point of water before it enters the HEPA filter unit. The engineering specification for the preheater unit is 24590-HLW-3PS-MEE0-T0001. The HEPA filter unit (HOP-HEPA-00001A/2A ; or its companion HOP-HEPA-00001B/2B) provide high efficiency filtering of submicron particulates from the offgas stream. "Two sets of three parallel cylindrical HEPA filter banks provide a minimum particulate removal efficiency of greater than 99.999% for 0.3 micron particles"..(and larger). Servicing consists of remotely changing out HEPA filters, once the differential pressure drop across a filter exceeds a design selected upper limit value. The "System Description for HLW System HFH, Filter Cave Handling System" (24590-HLW-3YD-HFH-00001, Rev 1) was also reviewed. Besides the system description for the HLW off-gas treatment, the BNI "Engineering Specification for HEPA Filters" (24590-WTP-3PS-MKH0-T0002 Rev 0 ; DWP010) was another important source document for information needed in this assessment. One of the most unique aspects of the WTP HLW off-gas HEPA filter design is that it will use a cylindrical configuration. Other HEPA filter designs within the EM vitrification work all use a rectangular slab configuration. BNI and the design/vendor are preparing documents to support why this design approach is acceptable relative to US code requirements for such filters. Another strong supporting consideration for the design and application of these HLW offgas HEPA filters is that each one of them will be tested, in a US (DOE) test facility and certified as acceptable (per ASME AG-1, Article FC-5100) before installation and use at the WTP. The design/fabrication/installation of the HEPA filter system, in the HLW vitrification facility, is proving to be somewhat challenging for BNI, simply because of the limited space available. Performance and servicing needs will have to be met by the final design solution to these challenges.

Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The HEPA filtration system has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

"Engineering Specification for HEPA Filters" (24590-WTP-3PS-MKH0-T0002 Rev 0 ; DWP010) The BNI design documentation, and the relatively robust history of HEPA unit design development, and applications, not withstanding the general lack of experience in the US with radial configuration units, provides ample evidence that the design will support the treatment needs, per the WTP Contract goal of 3MTG/d/melter.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The HEPA filtration system has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The general conservative approach being followed for designing these HEPA filter units for WTP HLW vitrification should provide ample margin to accommodate the treatment needs of the proposed ORP stretch case for increased HLW glass production rate. One important capability for accommodating the possible increases in deposition rate of filter loading is that the servicing schedule could be modified to help deal with this.

ORP Assessment –Secondary Stage of HLW Off-gas Treatment System

After discharge from the HEPA filter treatment unit, the HLW offgas enters what the BNI WTP HLW design calls the "secondary offgas treatment system", and this system is designed to remove mercury, halides-including I-129, volatile organic compounds and nitrogen oxides.

Booster Fan (Preheater and Booster Extraction Fans

These units of the HLW offgas treatment system will not be addressed here other than to note that the BNI design records were generally reviewed. Their design, although still underway, should comfortably address the design/performance needs of the HLW offgas treatment system. However, it is worth noting that like some other units in the HLW offgas treatment system, the booster extraction fans have presented some recent challenges, regarding design options/desired performance from each fan unit, etc., relative to sizing issues and the limited installation space available in the HLW facility.

Activated Carbon Unit (Hg Removal)

The principal function of this treatment unit, within the secondary stage of the HLW offgas treatment system, is to remove mercury (Hg) from the incoming off-gas. In an earlier BNI design configuration, this unit was located near the end of the secondary stage system, but concerns over possible mercury contamination of upstream units in that design (e.g., the thermal catalytic oxidizer unit, for organic destruction), lead to reconfiguring the order of the treatment units in the secondary stage treatment system. Both this activated carbon column unit and the silver Mordenite unit, for I-129 and other halides, were located up near the front of the secondary stage treatment system.

The activated carbon column unit consists of "two beds housed in two chambers." The beds are arranged for a series flow-path for treating the incoming offgas (i.e., Hg removal), and once Hg is detected as breaking through the leading unit, then the flow-path is switched to make the trailing the leading unit in this treatment pathway. During the time that it takes to change-out and replace the loaded unit (former leading) unit, the remaining unit will have to satisfy the treatment performance needs. The units are being designed to conservatively meet the needs of the treatment design, including operational scheme.

Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The Activated Carbon unit has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The BNI design documentation, including the engineering specification and perspective on R&T testing work, indicates that the design of the activated carbon treatment unit (for Hg removal) will be robustly designed to meet the needs of the secondary stage of the HLW off-gas treatment system, per the WTP Contract goal for HLW glass production (3MTG/d/melter). An important flexibility, regarding the ability to meet the needs of filter burden accumulation, is that it is being designed to be replaceable.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The Activated Carbon unit has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

As noted above there is ample evidence that the BNI conservatism being incorporated into the design for the activated carbon unit (Hg removal) should provide ample margin to enable this particular treatment unit of the HLW secondary offgas stream to support the ORP stretch case increase in HLW glass production rate. An important flexibility, regarding its ability to accommodate higher rates of filter burden accumulation, is that it is being designed to be replaceable.

Silver Mordenite Unit

The silver mordenite unit (HOP-ABS-00002) functions include trapping out iodine (especially I-129 isotope) and other halides (chlorine and fluorine), from the secondary stage of the HLW offgas, before the offgas reaches the thermal catalytic oxidizer (destruction of volatile organics) (skid) and the NO_x selective catalytic reducer (skid). The removal efficiency for iodine removal is listed as "99.9% for temperatures between 300°F to 390°F (24590-HLW-MKC-HOP-00002). The engineering specification for this unit was also reviewed (24590-HLW-3PS-MBT0-TP001 Rev 1 ; DWP-010) The silver is loaded on to the mordenite (elite –inorganic solid) and reduced to metallic silver to enable it to interact with and thus trap the subject halide (contaminants) in the incoming offgas stream. The incoming offgas will come into an overhead plenum region of this treatment unit and then flow down through a matrix of several dozen canisters (cartridges) containing this treatment media. The unit will be monitored for halide break-through downstream of the canisters, and their replacement is expected to be relatively simple and quick, so with the concentration burdens of these respective contaminants expected to be relatively low in the offgas stream, this should work in favor of the servicing demands being modest.

Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate (3MTG/d/melter)

Conclusion:

The silver mordenite unit has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The BNI design documentation, including the engineering specification and perspective on R&T testing work, indicates that the design of the silver Mordenite treatment unit (for Hg removal) will be robustly designed to meet the needs of secondary stage treatment of the HLW offgas, per the WTP Contract goal for HLW glass production (3MTG/d/melter). An important flexibility, regarding the ability to meet the needs of filter burden accumulation, is that it is being designed to be replaceable.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The silver mordenite unit has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

As noted above there is ample evidence that the BNI conservatism being incorporated into the design for the silver Mordenite treatment unit (I-129 and other halides removal) should provide ample margin to enable this particular treatment unit of the HLW secondary offgas stream to support the ORP stretch case increase in HLW glass production rate. An important flexibility, regarding its ability to accommodate higher rates of filter burden accumulation, is that it is being designed to be replaceable.

Catalyst Skid

After treatment by the silver mordenite unit, the secondary (stage) offgas comes into what is called a skid unit in the BNI treatment design, and this skid consists of the following series of treatment units: 1) a preheater unit (HOP-HX-00001) (basically a heat exchanger) that provides waste heat to the incoming gas, and 2) a heater unit (HOP-HTR-00001), which finishes the needed heating of the incoming off-gas, and 3) a Thermal Catalytic Oxidizer (TCO) (HOP-SCO-00001) that is used to destroy volatile organics, and 4) with the injection upstream of ammonia, the offgas goes into the Selective Catalytic Reducer (SCR) (HOP-SCR-0001) that is used to destroy NO_x and from there the now fully treated HLW offgas stream exits the HLW facility via the stack discharge (to the air). This "catalyst skid" of treatment units performs a set of important contaminant destruction tasks, which are essential for compliance with the environmental permitting relative to the HLW facility.

The skid system will be monitored for performance of its treatment functions (i.e., contaminant destruction), and to watch for the effects of degradation of the respective catalysts from build-up of possible contaminants from the offgas stream. Thermal control of the various units on the skid is an essential parameter for effective and efficient performance of the two catalyst treatment units. Both of the catalyst units can be serviced for change-out of the media, and service by-pass lines and monitoring are incorporated into the skid system design.

An especially important factor in the support to the design for these catalyst treatment units is that R&T testing that has been done with the HLW scaled vitrification system (DM-1200 system at VSL) that includes the prototypic scaled HLW off-gas treatment system. And of particular importance is the fact that an extensive series of testing called the MACT tests (Test Plan for LAW and HLW tests....VSL-04T4830-1), is currently being performed, regarding the test system and especially the TCO unit's ability to effectively destroy volatile organics.

Ability to Support WTP Contract Requirement for HLW Glass Throughput Rate(3MTG/d/melter)

Conclusion:

The catalyst skid system has sufficient design capacity to support melter operations at 3.0 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

The BNI design documentation, including the engineering specification and perspective on R&T testing work, indicates that the design of the skid catalyst treatment units will be robustly designed to meet the needs of secondary stage treatment of the HLW offgas, per the WTP Contract goal for HLW glass production (3MTG/d/melter). The current on-going MACT testing will provide important confirmation regarding the destruction of volatile organics. An important flexibility, regarding the ability of the catalyst treatment units (TCO and SCR), on the skid, is that they are designed for servicing the units and especially to replace their respective catalyst media.

Ability to Support An Enhanced Goal (~+25%) for WTP HLW Glass Throughput Rate:

Conclusion:

The catalyst skid system has sufficient design capacity to support melter operations at 3.75 MTG/d with the range of glass yields discussed in Appendix A.

Discussion:

As noted above there is ample evidence that the BNI conservatism being incorporated into the design for the silver Mordenite treatment unit (I-129 and other halides removal) should provide ample margin to enable this particular treatment unit of the HLW secondary off-gas stream to support the ORP stretch case increase in HLW glass production rate. An important flexibility, regarding the ability of the catalyst treatment units (TCO and SCR), on the skid, is that they are designed for servicing the units and especially to replace their respective catalyst media.

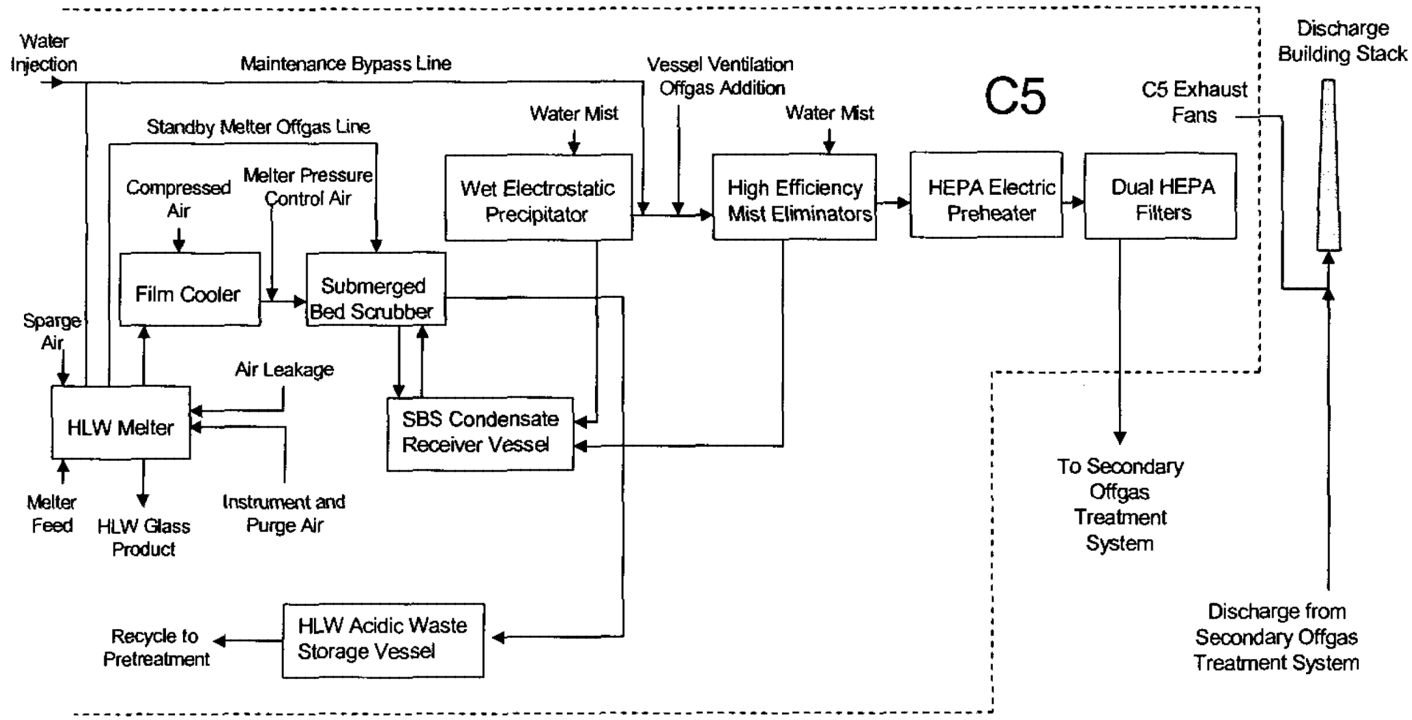

Figure C-1 Block Diagram of Primary Offgas Portion of Offgas Treatment System for HLW Vitrification Facility

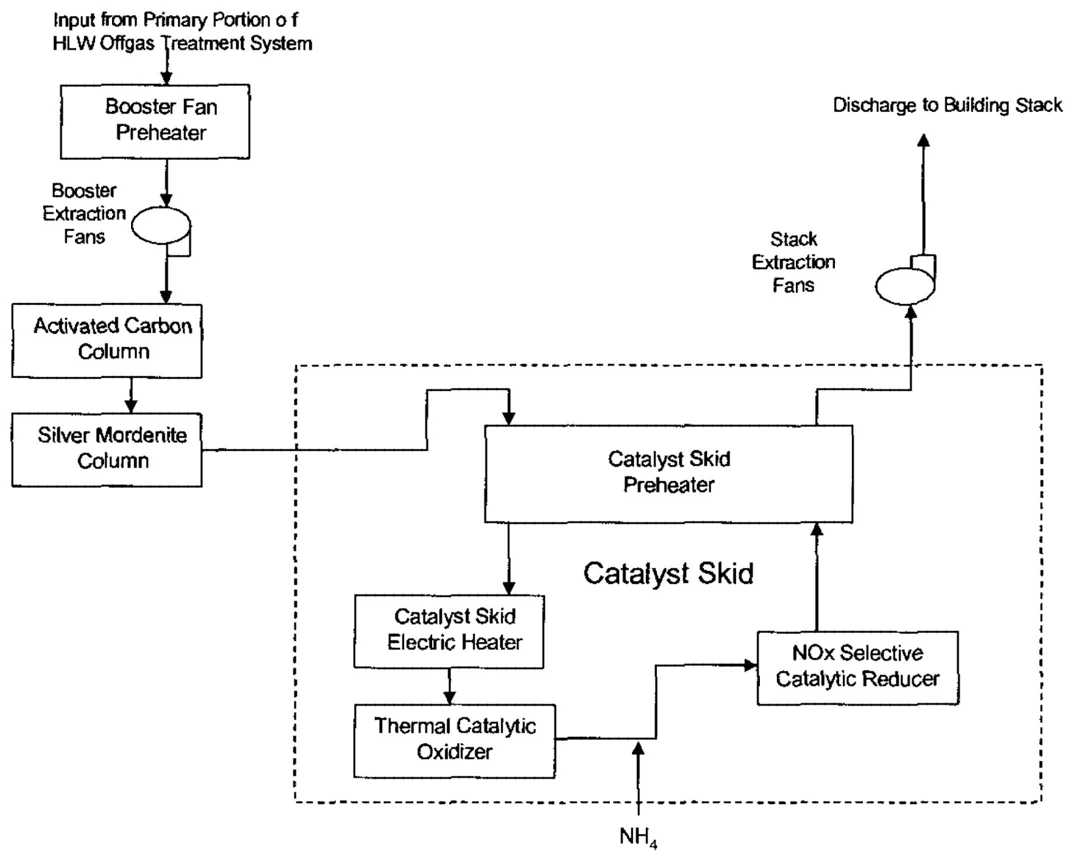

Figure C-2 Block Diagram of Secondary Portion of Offgas Treatment System for HLW Vitrification Facility

References

1. 24590-HLW-3YD-HOP-00001, Rev 0, "System Description for HLW Melter Offgas Treatment Process and Process Vessel Vent Extraction (HOP and PVV Systems", November 11, 2002, Bechtel National, Inc., Richland Washington.
2. 24590-HLW-DVR-M-03-004, Rev 0, "Design Verification For HLW Melter Off-Gas System (HOP)", December 31, 2003, Bechtel National, Inc., Richland Washington.
3. WTP Contract, DE-AC27-01RV14136, Office of River Protection, Richland, Washington
4. 24590-WTP-DB-ENG-01-001, Rev 1B, "WTP Basis of Design", June 3, 2004, Bechtel National, Inc., Richland Washington.
5. 24590-HLW-PER-PR-03-001 Rev A; DWP-010, "Description of HLW Vitrification System Bypass Events", Bechtel National, Inc., Richland Washington.
6. 24590-HLW-PYC-HOP-00002, "Sizing Basis for HLW Offgas Lines",April 5, 2004, Bechtel National, Inc., Richland Washington
7. 24590-HLW-MKD-HOP-00016, Rev 3, "HLW Submerged Ben Scrubber", November 30, 2004, Bechtel National, Inc., Richland Washington
8. 24590-MKD-HOP-00006, Rev 1, "Mechanical System Data Sheet (SBS)", Bechtel National, Inc., Richland Washington
9. 24590-HLW-PYC-HOP-00003, "Maximum Wall Temperature of HLW Mleter Off-gas Piping", June 14, 2004, Bechtel National, Inc., Richland Washington
10. 24590-HLW-MEC-HOP-00008 Rev B, "HLW Submerged Bed Scrubber Cooling Jacket Effectiveness", September 24, 2002, Bechtel National, Inc., Richland Washington.
11. 24590-HLW-MEC-HOP-00011 Rev A "Design of Cooling Jacket for HLW SBS Column Vessel", September 8, 2002, Bechtel National, Inc., Richland Washington.
12. 24590-HLW-MKC-HOP-00003 Rev B, "Sizing of the HLW Submerged Bed Scrubber Column and Vessel", August 2, 2002, Bechtel National, Inc., Richland Washington.
13. 24590-HLW-M6C-HOP-00005, Rev A, "Sizing of the SBS Condensate Receiver Vessel HOP VSL-00903 and VSL-00904", December 13, 2002, Bechtel National, Inc., Richland Washington.
14. 24590-HLW-M4C-30-00003, Rev B, "HLW Vitrification Facility Feed and Effluent Design Basis Flowsheets", July 7. 2004, Bechtel National, Inc., Richland Washington.
15. 24590-HLW-MKD-HOP-00002 Rev 2, "Process Data Sheet (WESP)", September 30, 2004, Bechtel National, Inc., Richland Washington.
16. 24590-HLW-MKC-HOP-00011, "Process Design of HLW Offgas High Efficiency Mist Eliminator", November 18, 2003, Bechtel National, Inc., Richland Washington.
17. 24590-HLW-MVD-HOP-P0007 Rev 0 ; DWP015, "HLW Primary Offgas HEME", April 22, 2004, Bechtel National, Inc., Richland Washington.
18. 24590-HLW-3PS-MEE0-T0001, "Engineering Specification for the HEPA Filter Prefilters", July 10, 2004, Bechtel National, Inc., Richland Washington.
19. 24590-HLW-3YD-HFH-00001, Rev 1 , "System Description for HLW System HFH, Filter Cave Handling System", October 31, 2003, Bechtel National, Inc., Richland Washington.
20. 24590-WTP-3PS-MKH0-T0002, Rev 0 ; DWP010, "Engineering Specification for HEPA Filters" August 19, 2004, Bechtel National, Inc., Richland Washington.
21. 24590-HLW-3PS-MBT0-TP001 Rev 1 ; DWP-010, "Engineering Specification for the Silver Mordenite Design and Fabrication", September 26, 2004, Bechtel National, Inc., Richland Washington.

22. 24590-QL-POA-MKED-00001-14-01, Revision 008, "Component Modularization Plan," WESP, April 2004, Bechtel National, Inc., Richland, WA.

AUDIT NOTES
Section D
CANISTER PROCESSING AND HANDLING SYSTEMS

Introduction

Figure D.1 shows schematically the path of the IHLW canisters into, through and out of the HLW facility. This figure shows the canister processing and handling activities for the following systems:

HRH – Canister Receipt Handling (24590-HLW-3YD-HRH-00001, Rev 1) provides the mechanical equipment, controls and instrumentation required for importing IHLW Canisters into the HLW facility. The functions of this system include receipt and staging an empty canister, inspecting the canister and transfer through the Canister Import Room and Import Tunnel for transfer to the Canister Handling Cave. The system includes the:

- Clean Canister Import Bay (C1/R1)
- Import Room which contains a buffer rack that has 16 spaces for storage of empty inspected canisters (C2/R2)
- Clean Canister import tunnel system (C3/R3)

This is a clean, low radiation system so maintenance and repair activities are performed within the rooms. A Bogie maintenance bench is provided in the import tunnel for that purpose.

HPH – Canister Pour Handling System (24590-HLW-3YD-HPH-00001, Rev 0) transports the empty product canisters and full IHLW canisters within the HPH system facilities and performs canister sampling, lid closure and rework, if required. The system operates in two areas:

- The Canister Handling Cave includes a crane decontamination area, a crane maintenance area, weld stations, canister cooling racks (24 positions) and canister buffer racks (24 positions).(C5/R5)

- Pour tunnels for melters 1 and 2 containing bogie maintenance areas. (C5/R5)

This system transports canisters to and from the melter pour spout for filling. Two pour tunnel bogies per melter are provided for this purpose; each bogie is dedicated to one of the two melter pour spouts. The pour tunnel bogies are driven by push pull chains so there is no drive motors on the bogies themselves. They can be retrieved manually and maintenance is performed in dedicated areas after decontamination.

The only function performed by the melter systems (HSH, HMP) is to fill the canisters. They do not have any canister handling functions.

The weld station has two positions which can be used for measuring the temperature of the canister flange, measuring the level of glass in the canister, taking glass shard samples and transporting them out of the cave for analysis and welding on the lid.

The canister cooling racks store the filled canisters while they cool from ~900 °F skin temperature to 350 °F prior to welding on the canister lid. This is estimated to take about 72 hours from initial storage. The canisters cool for 9 hours after the last pour prior to being transported to the cooling racks. The canister buffer rack temporarily stores empty canisters or full canisters that have cooled sufficiently to be welded (< 350 °F). This rack is not capable of storing canisters at temperatures above 350 °F.

Maintenance of the major equipment, (e.g., the cranes and bogies) is performed "hands-on" in the dedicated maintenance areas after decontamination. The racks are modular with sections that can be transported to the crane maintenance or general maintenance area for maintenance or repair. Special out-cave features are provided to retrieve failed cranes or bogies and to open or close doors and hatches. Hatches can be removed using the cranes and bales located on the top of the hatches.

<u>HDH—Canister Decontamination System</u> (24590-HLW-3YD-HDH-00001 & -00002) removes smearable radioactive contamination from the filled and sealed canister surface to meet the IHLW requirements. The system takes the filled and sealed canisters from the HPH system and decontaminates them using a ceric nitrate bath with nitric acid and demineralized water rinses. The canister surface contamination levels are confirmed to be within specification requirements at the canister swab and monitor station. Once confirmed clean, the canisters are transported to the canister storage and export system.

The system includes two areas:

- Canister Swab and Monitor Cave which includes two decontamination bath and rinse vessels, a canister swab and monitor station, including swabbing turntable, and a transport crane (C3/R3/R5)

- Canister Storage Transfer Tunnel (C3/R5) which contains the transfer bogie used to transport the canister from the canister handling cave to the canister storage and export cave.

All maintenance of the cranes and bogies is performed "hands-on" in dedicated facilities after decontamination. Special out-cave features are provided to retrieve failed cranes or bogies and to open or close doors and hatches. Hatches can be removed using the cranes and bales located on the top of the hatches.

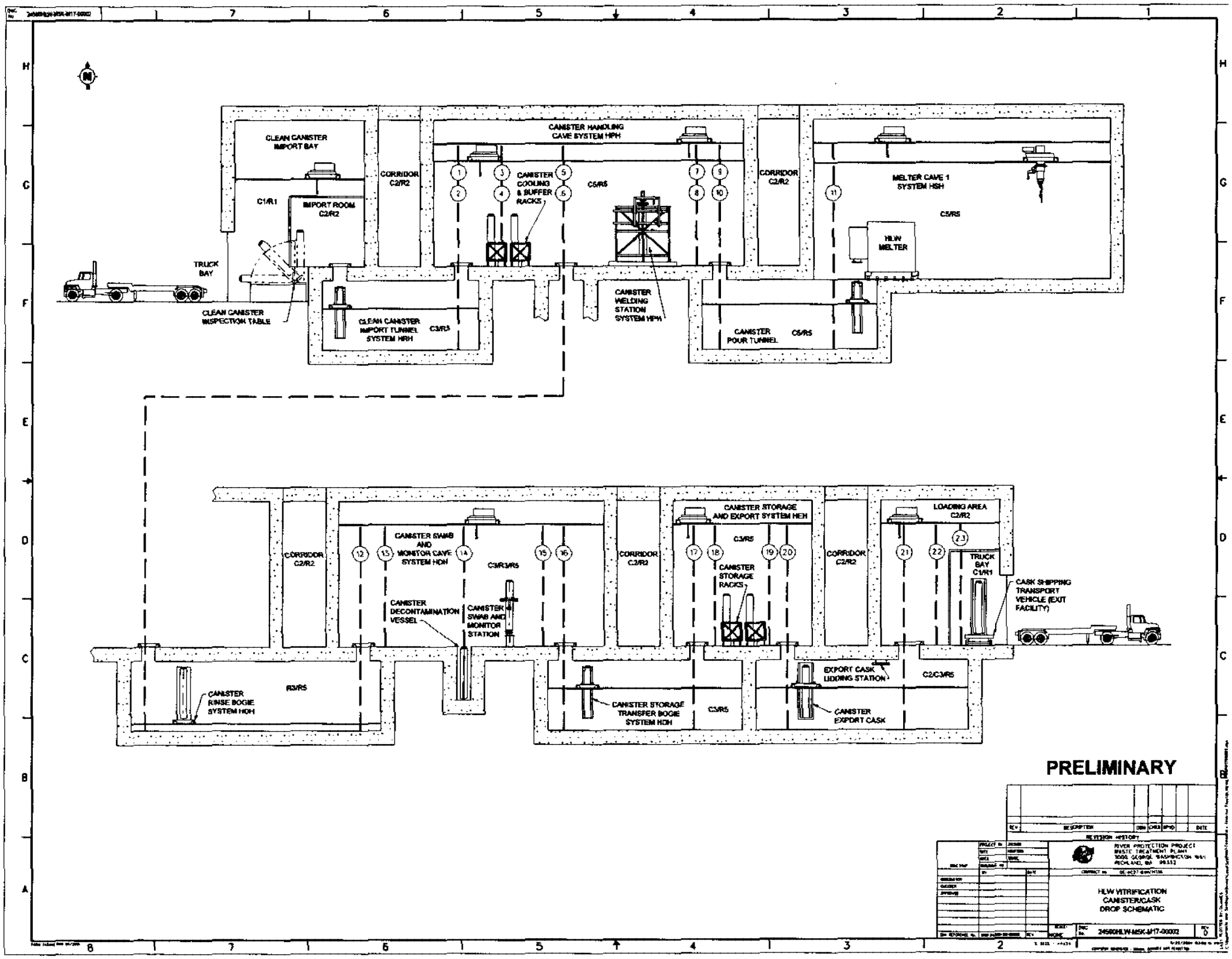

Figure D.1 Canister Handling Schematic

HEH – Canister Export Handling System (24590-HLW-3YD-HEH-00001, Rev 0) receives "clean" canisters from HDH, racks them in temporary storage, prepares canisters for shipment, imports a clean shipping cask, loads a canister into the cask and exports that cask out of the facility for shipment to the Canister Storage Building.

The system includes the following areas:

- Canister Storage Area that contains the crane to retrieve a canister from HDH and to position a canister in the canister export cask located in the canister export tunnel and racks to store up to 46 canisters for export. One of the racks can be used for positioning and supporting the canister grapple for maintenance and repair. (C3/R5)
- Canister Export Tunnel which contains a bogie for transport of the export cask from the canister storage area to the cask loading area and a mechanism for removal and replacement of the cask lid. (C2/C3/R5)
- Loading Area to bring an empty cask into the facility and export a filled cask outside the facility. The cask bolts are removed in this area when the cask is brought in prior to transfer to the transfer tunnel and then are replaced here when the filled cask is returned. The crane in this area is used to transport the cask between the transfer tunnel and the truck bay.
- Truck Bay contains the crane and trailer that are used to transport the cask into and out of the facility.

All of the equipment is to be maintained "hands-on" after any required decontamination. Special features are provided to retrieve failed cranes and bogies for repair and to open or close doors and hatches remotely if required

The following table summarizes the expected times for each of the steps taken in each system as a canister enters the facility, is filled, cooled, sealed, decontaminated, swabbed and monitored and exported to the export cask. These estimated times are provided by BNI in the form of an Excel spreadsheet that are used as input to the Operations Research model. This spreadsheet is not currently documented but will be made part of the System Descriptions for these systems early next year. These times are used in the Operations Research (Witness) Model (24590-WTP-MDD-01-001). The following discussions are based in part on these estimated times, (e.g., the times required for pouring, initial cooling and times in the cooling racks prior to welding on the lid).

Table D.1 Estimated Times to Perform Key Activities of HLW Canister Processing

Step*	Description	Time, Minutes	Comments
1	Transfer canister to the inspection/rotation table	28	
2	Unwrap and inspect canister	11	
3	Transfer the canister to the import bogie	58	If the import bogie is in use the canister is transferred to the import buffer rack (31 min). When the import bogie is free the canister is removed from the rack and placed in the bogie (52 min)
4	Transfer to the handling cave import hatch	7	
5	Transfer from import bogie to pour cave tunnel bogie	46	If all pour cave bogies are in use the canister is placed in the handling cave buffer rack (38 min). When a pour cave bogie is free a canister is transferred to the bogie from the handling cave buffer rack (23 min)
6	Transfer to melter pour spout	8	
7	Pour time	1350	Based on pouring one canister every 24 hours; next melter pour starts 90 minutes after the end of the preceding pour
8	Cooling time	578	Includes 60 minutes in the pour position and 480 minutes about 6 feet displaced from the pour position
9	To cooling rack	27	
10	Cooling time in rack		~ 72 hours is estimated -- there are 24 positions for cooling. The canister flange must be 350F or less to transfer to the weld station.
11	Move to weld station	21	
12	Level Measurement, sampling and welding	498	There are two stations so a lid can be welding while the level measuring and sampling are taking place in the other station
13	To canister rinse bogie	26	

Step*	Description	Time, Minutes	Comments
14	Move to rinse station, rinse and move to decon hatch	62	
15	Move into decon vessel (one of two)	62	There are two decon vessels that can be used simultaneously
16	Cerium IV decon bath (one of two)	566	
17	Nitric acid and water spray rinse	100	
18	Canister drying	31	
19	Move to swabbing station and swab bottom	92	
20	Complete canister swabbing	98	
21	Move to canister transfer bogie	45	
22	Move to canister store import hatch	4	
23	Transfer to canister storage rack	45	
24	Canister remains in storage until accepted by CO (ICD-14)		
25	Import cask on trailer in to export bay	101	
26	Transfer cask from trailer to cak handling bogie	61	
27	Unbolt lid, transfer to unlidding station, remove lid, position cask for receipt of canister	59	
28	Transfer canister from storage rack to cask	51	
29	Transfer cask to lidding station, replace lid, transfer to loading area, reattach and torque cask bolts	53	
30	Transfer cask to transport trailer	117	
31	Transport trailer departs	31	
32	Miscellaneous tasks and paperwork	120	

* Note that these step numbers do not correspond with the numbers shown on Figure D.1

The following discusses the results of the specific lines of inquiry for the Canister Processing and Handling Systems Oversight.

Heat removal capacity for pour cave and finishing line

Conclusion:

Design analyses performed for bounding canister and system conditions at a glass production rate of 3MTG/day per melter confirm that the HLW C5 system is capable of maintaining area, ventilation air exit and structure temperatures within required ranges.

The effect of increasing the glass production rate by 25 % would be to increase the most limiting heat load in the pour cave tunnels by ~15 % to 17%. This is within the design conservatism of the heat transfer analyses and the design margins in the system for area and ventilation air exit temperatures. Although it is judged that structural temperatures will also be acceptable during pouring, additional CFD analyses would be required to confirm that the potentially higher canister temperatures that may be reached during pouring do not result in excessive structural temperatures.

Discussion:

System Description

As shown above the several areas that comprise the canister handling system include C1 through C5 areas. The more critical of the ventilation paths is the C5 path that maintains contamination control and temperature in the higher contamination potential and higher temperature areas of the system. These are the canister handling cave and the pour cave. The canisters are filled and stored while cooling in these areas prior to moving through the balance of the facility. Accordingly, they have the highest heat loads in the HLW facility.

The C5 ventilation system functions to maintain pressure differentials, and air flow direction, from areas of lesser contamination potential (C1, C2, C3 areas) to areas of greater contamination potential (C5). It also uses air in-bleeds from the C3, C2 areas to maintain C5 area temperatures between 59 °F and 113 °F. The inlet temperatures to the C5 areas from C3 are controlled with water cooled heat exchangers. There are no air coolers in the HLW C5 system. HEPA filters are provided on the in-bleeds. These filters have several functions:

- Control the cascade air flow,
- Control the pressure differentials between confinement boundaries
- Provide a physical boundary or zone isolation in the event of fire or smoke. This function is provided using fusible link actuated fire dampers and smoke actuated isolation dampers.

The C5 system includes two 100% exhaust fans and two stages of HEPA filtration on the discharge to the environment.

System heat loads

The heat loads in the handling area are based on equipment and piping heat production and heat release from the canisters. (24590-HLW-RPT-HV-03-002, Rev 3 HLW Facility Heat Gain Assessment – Process Equipment, calculations 24590-HLW-MAC-C5V-00001, -00002, -00003, -00004, -00005, -00006). When not in the pour or initial cooling phase the heat release rate when canisters are in the canister handling and swab and monitor caves is assumed at 1200 watts. In the export caves the canister heat release rate is based on fully cooled heat release rate of 300 watts. These are judged as bounding values by BNI for the purposes of the heat load calculations. There is no documented basis for these heat rates. However the fully cooled heat release rate of 300 watts is expected based upon an RPP mission average heat release rate.

During the pour and initial cooling phases of canister filling and handling, the canister heat release rates and air and structure temperatures in the pour tunnel and canister storage areas are calculated using Computational Fluid Dynamic (CFD) and two dimensional transient canister heat transfer analyses. (24590-HLW-M8C-C5V-00010, 24590-HLW-M8C-C5V-00001 through -00009). These analyses use bounding values of glass properties to maximize the heat release rates in the two areas. For example, high thermal conductivity glass will produce higher short term heat release rates, which would be bounding while the canister is resident at the pour spout for filling and near the pour spout in the initial 9 hour cooling phase. Lower conductivity glass will produce higher heat release rates later that may be more limiting during canister cooling in the cooling racks.

The results of these calculations verified that the ventilation airflow and the insulation on the tunnel structure are sufficient to maintain area air temperatures, ventilation air exit temperatures and structure temperatures within specified levels.

The margin in these calculations is derived from several factors:

- The use of bounding glass properties. These were based on calculations and literature search. There is no intent to verify these values. Some actual data was taken on time dependent temperature profiles on filled canisters during melter development work. However, the ambient airflow and temperature conditions were not consistent with those expected during operation so the results are not useful for the purposes of establishing margin.

- Heat loads are increased by 15% in the design calculations for the ventilation system.

- Static pressures are increased by 20% to provide margin for future changes to the system static pressure.

- Lighting loads are assumed at full capacity and 100% utilization

The cave heat loads are based on the following number of canisters and heat release rate:

Area	Number of Canisters	Heat Release Rate
Pour Tunnel Bogies	2	Heat release rate calculated by CFD
Canister Handling Cave	40	1200 KW
Decon/Swabbing/Monitor Cave	2	1200 KW
Canister Storage Cave	48	300 KW

The number of canisters in each location assumes a canister is present in each workstation. This is judged a realistic assessment of the heat loading.

Impact of Production Rate on Heat Load

The calculations discussed above were made assuming a melter production rate of one canister of HLW glass per day per melter; about 3 MTG/day/melter. As noted the principal heat load in the pour caves occurs during canister pouring and cooling. The timeline summarized in Table D.1, shows that the canister is filled in 12 increments of 2 hours each comprising ½ hour pour time, 1-1/2 hour melter recovery time. The filled canister is then cooled in the pour cave for an additional nine hours (one hour under the pour spout and 8 hours about 6 feet down the tunnel). The heat transfer calculations mimic the pour sequence by introducing heat sources at the canister position representing multiple pours (6 to 12 depending on the nature of the analysis) over a 24 hour period. Transient heat transfer analyses are used to calculate the heat release rates and the canister temperatures during the pour and cooling phases.

The WTP Contract requires a design HLW production rate of 3 MTG/day per melter and a net production rate of 480 HLW canisters per year. At 3.1 MTG per HLW canister these requirements are equivalent to a facility availability of 68 %.

480 cans/year x 3.1 MTG/can ÷ 365 days/year ÷ 6 MTG/day = 0.68

The current Operational Research Analyses (24590-WTP-RPT-PO-03-045, Rev 0) predicts a worse case HLW facility availability of 72% assuming current melter bubbler replacement rates, addition of Lab RAM data and 15% sample rework and limited model development.

The ORP Stretch Case (completion of processing by the end of 2025) requires a net production rate of 615 HLW canisters per year. At an assumed availability of ~70% the peak production rate of the HLW facility would have to be 3.75 MTG/day/melter to achieve a net production rate of 615 canisters per year.

*615 cans/year x 3.1 MTG/can ÷ 365 days/year ÷ 0.70 availability ÷2 =
3.75 MTG/day/melter*

This is a 21% increase in peak production rate or one HLW canister per melter every 20 hours.

From a heat load perspective the principal effect of the higher melter capacity is to increase the heat release rate and the canister temperatures during pouring. The total time that a canister will remain in the pour tunnel prior to transfer to the cooling racks will be approximately the same, (i.e. ~33 hours) since it is dependent on the canister temperature. The total amount of heat released over that period will, therefore, also be approximately the same as currently calculated. However, to bound the increase in the heat release rate during pouring we shall assume that the same amount of heat is released during a 20 hour pour as is calculated for the 24 hour pour in the CFD analyses. The heat release rate calculated during the 24 hour pour is shown in Figure D.2 (Figure 2 from the CFD analyses). The average heat release rate over the 24 hours of pouring is about 64,000 watts (based on integrating the area under the heat release curve and dividing by 24 hours). The heat release rate would be 20% higher to obtain the same total heat release in 20 hour; i.e., an increase of 12,860 watts (43,890 Btu/hr).

The HLW HVAC sizing calculation (24590-HLW-MAC-C5V-00004, HLW C5V HVAC Equipment Sizing and Selection) is based on Melter Pour Cave heat loads of ~290,000 Btu/hour (24590-HLW-MAC-C5V-00002, -00003). The 43,890 Btu/hour increase in heat release rate is a 15 % increase in the overall pour tunnel design rate. As noted above there is at least 15% margin in the design of the ventilation system. It is judged, therefore, that the ventilation system will maintain area temperatures and air leaving temperatures in the acceptable range if the pour time was reduced from 24 hours to 20 hours.

The CFD analyses were performed for the canister temperatures associated with 24 hour pour period. During the pour period radiation is an important factor in calculating the temperature on the insulation at the walls, ceiling and floor. It is likely that the temperatures on the canister surface may be higher during a 20 hour versus a 24 hour pour period. The low conductivity of the glass, however, would tend to minimize the differences. A new CFD analysis would be required to verify that the insulation thicknesses are adequate to maintain the concrete and structural temperatures within design limits. It is judged, however, that these analyses would show that the temperatures are acceptable.

It is concluded, therefore, that the pour cave ventilation system is adequate to support a melter production rate of ~3.6 MTG/day to 3.75 MTG/day that would be required to achieve the ORP Stretch Goal net production rate of 615 canisters per year (assuming a 72% HLW facility availability).

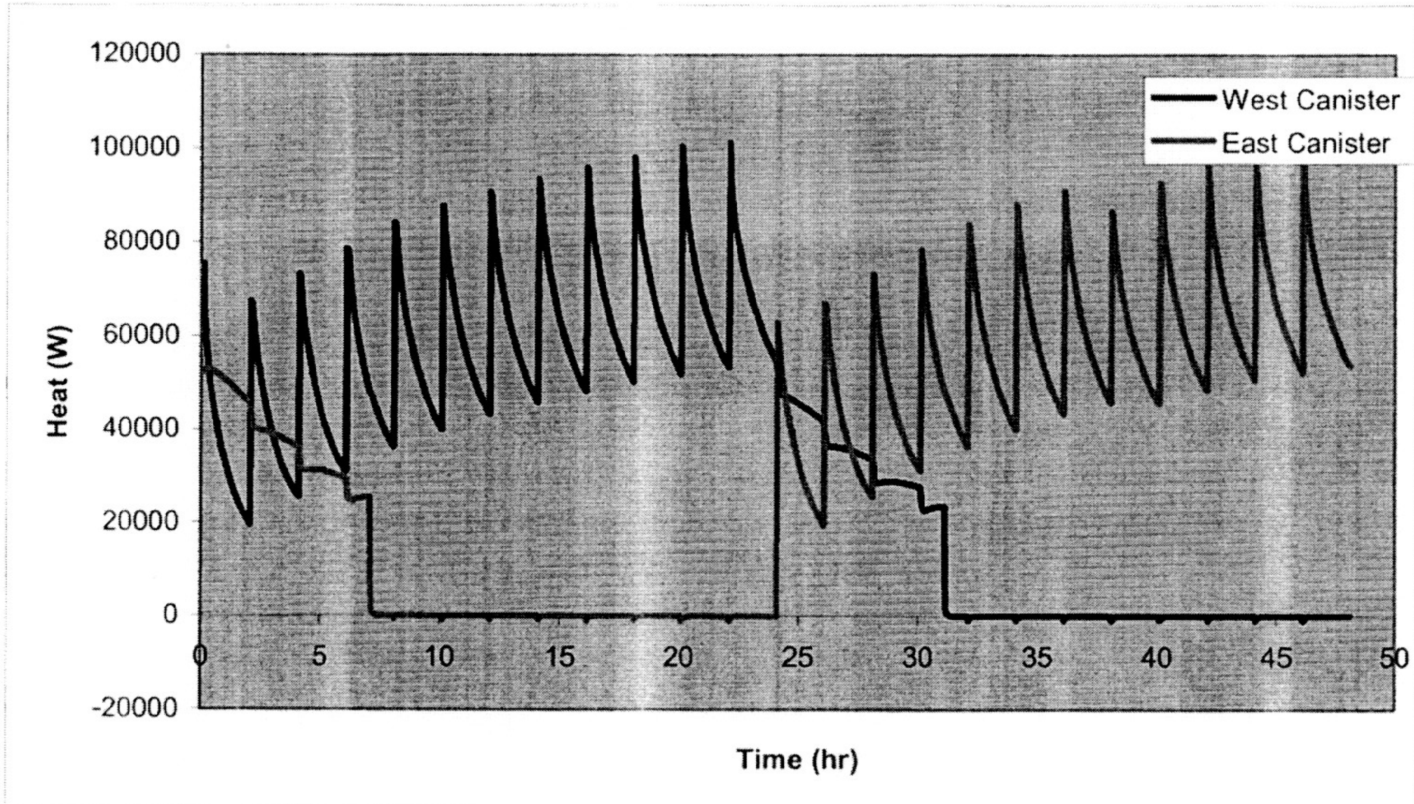

Figure 2. Canister Heat Rate During One Complete Cycle

Figure D.2 Calculated Canister Heat Release Rates during Pouring and Initial Cooling

Canister Cooling Rate for Production and Canister Ship out Requirements

Conclusion:

The canister processing and handling line includes sufficient provisions to store canisters during cooling and processing to support the WTP Contract net production rate of 480 canister per year and the ORP Stretch Goal of 615 canisters per year. These include the Cooling Racks and Buffer Rack in the Canister Handling Cave and the Storage Rack in the Export Cave.

Discussion:

The timeline shown in Table D.1 shows that once a canister has completed filling it remains in the pour position for 1 hour and then adjacent to the pour spout for an additional 8 hours before being transferred out of the pour tunnel to the Canister Handling Cave for storage in the Cooling Racks. The nine hours after pouring is the time required for the canister neck temperature to be acceptable for grappling (~900 °F). The canister will then remain in the Cooling Rack until its flange temperature drops to about 350 °F; the temperature at which it is acceptable to weld on the lid. This is estimated to take about 72 hours. Over that period each melter will have produced three more canisters. The time required for a canister to progress from the cooling rack to the export tunnel storage rack is 1622 minutes (Table D.1 steps 9-23) or ~27 hours. By that time the canister has been through several rinse and decontamination cycles and its temperature is acceptable for transfer to the export cave for storage until transfer out of the facility.

There are 24 positions in the canister cooling racks and 24 positions in the buffer rack. The buffer rack can not receive canisters that are not cooled to the weld temperature. At the rate of 2 canisters filled every 24 hours it would take 12 days to fill the cooling rack. This might occur, for example, if one of the transfer bogies in the canister handling areas were out of service for an extended time. The canisters cool to weld temperature in 72 hours so the cooler canisters in the cooling rack could be moved to the buffer racks for storage until the downstream part of the finishing line were back in service.

There is therefore, 24 days of storage in the canister handling cave at the production rate of 3 MTG/day. At the higher rate necessary to support net production of 615 canisters per year, 3.75 MTG/day, there would be ~20 days of storage. This is judged to be sufficient to let the canisters cool to required temperatures prior to further processing and export from the facility. This is also judged to be sufficient to permit repair or replacement of failed equipment to bring the finishing line back in service without requiring the melters to be put into idle mode.

Basis for Time Cycle for Canisters Batch Processing.

Conclusion:

The Operations Research (Witness) Model developed, operated and maintained by BNI is used to confirm the functionality of the WTP systems including those conducting HLW canister batch processing. The model runs to-date indicate that the systems will support a peak production rate of 3 MTG/day/melter and, after considering reliabiliy and repair data for the equipment, a net production rate of 415 Canisters per year with a ~15% margin (24590-WTP-RPT-PO-03-045, Rev 0). An assessment of the specific mechanical handling equipment indicates that the most limiting area is the decontamination station. Based on the current estimated timeline this station could support a peak throughput of 3.4 canisters per day. Accordingly, a utilization factor of 70% would be required to support the ORP Stretch Goal of ~2.4 canister per day peak production.

A brief review of the Operational Research Model resulted in the following observations and conclusions:

- Neither BNI Systems Engineering nor BNI Design Engineering complete reviews of the model input data or its configuration. Considering the critical role of this model in confirming the functionality of the plant, Systems and Design Engineering should have a more active role in confirming the veracity of the modeling.

- It is not clear how Human Factors are considered in the assessment of the Mechanical Handling System timelines. Human factors should be considered in assessing the functional capabilities of systems in which operator actions are required to complete system functions.

- The model does not appear to include the buffer rack in the Canister Handling Cave. It should be determined if the model includes the Canister Buffer Rack and, if it does not, provide justification for not including this rack in the model.

- This model is a valuable tool for confirming the functionality of plant systems and identifying potential pinch points in plant throughput. This model be kept up-to-date through plant cold and hot commissioning and be turned over to the operating contractor for use as a training and design modification tool during plant operation.

Discussion:

Table D.1 summarizes the estimated times to complete all of the functions required to import canisters into the HLW facility, fill the canisters, cool, inspect, seal, decontaminate, swab and monitor, store for export and export out of the facility. Figure D.1 shows the steps schematically. The ability of the HLW canister handling systems to support the required production rate of 3 MTG/day/melter is confirmed using the Operations Research Witness Model (24590-WTP-RPT-PO-03-045, Operations Research Assessment Report). This model provides a simulation of the processes and handling systems in the HLW facility including estimates of mean time to failure (MTBF), mean time to repair (MTTR), mean time to maintenance (MTBM) and mean time to complete maintenance (MTTM) of the process and mechanical handling equipment. A zero failure, zero maintenance run of the model confirms the peak production rate of the facility. The full failure/maintenance run confirms the net production capability of the facility. These runs assume a melter peak production rate of 3 MTG/day

Operational Research Model Review

A presentation made by BNI to address several questions on the OR modeling approach raised by ORP in this oversight was made on November 16, 2004. Following this presentation the Oversight Team witnessed a brief run of the model. The following are observations from the presentation and model witness.

- The model is developed from the process flowsheets provided by process engineering and timeline data for the mechanical handling equipment provided by mechanical design engineering. RAM data is initially developed during interactive sessions with System Engineering personnel. The RAM data is refined as information is obtained from equipment suppliers and the equipment specifications. The model development, operation and maintenance are the responsibility of Central Engineering/Process Operations.

- Neither Systems Engineering nor Design Engineering completed a review of the model. The model input data is reviewed and confirmed by Process Operations personnel. The results and assessment reports are reviewed by system and design engineering for reasonableness. This requires that the information provided to and being reviewed by the modelers is up-to-date with the plant design and equipment specifications and procurement. It also relies on the capabilities of the modelers to ensure the model is a valid representation of the plant design. Considering the critical role of this model in confirming the functionality of the plant, Systems and Design Engineering should have a more active role in confirming the veracity of the modeling.

- The results of the modeling have influenced the design of the plant by identifying areas where redundant components are required to ensure required throughput is achieved. The principal example is the addition of a second decontamination vessel. It was stated in the meeting with BNI personnel that the decision to recommend the addition of a component is made based on high utilization (~65% or above) required to meet throughput.

- It was stated in the meeting with BNI personnel that the mechanical handling system times are based on average equipment travel times; (i.e., the average of the minimum and maximum travel speeds cited in the equipment specifications). These are contained in an Excel spread sheet developed by Area Engineering. Some of these are also documented in Leam 2002 (CCN: 046869, "Step times for High Level Waste Systems Decontamination Handling and Export Handling", J. S. Leam, November 18, 2002). An update of these times and documentation of the full timeline is scheduled to be completed in early 2005. These times are not currently formally documented and controlled.

- The mechanical handling times include operator actions in addition to the mechanical equipment functions. These are intended to address partially human factors in performing the operator functions. It is not clear human factors are considered in the assessment of the Mechanical Handling System.

- Based on the witness of model operation, the model does not appear to include the buffer rack in the Canister Handling Cave. This rack permits storage of up to 24 cooled canisters prior to entering the balance of the finishing line. Use of this storage permits continued operation of the melter for up to 24 days if the balance of the finishing line were out of service due to equipment failure.

This Operational Research model is a valuable tool for confirming the functionality of plant systems and identifying potential pinch points in plant throughput. This model should be kept up-to-date through plant cold and hot commissioning and be turned over to the operating contractor for use as a training and design modification tool during plant operation.

Finishing Line Throughput

Table D.1 summarizes the times for each major activity in the canister handling and processing systems. An objective in operation of these systems should be that the melter production rate be the most limiting factor in facility throughput. In Table D.1 this is set at one canister every 24 hours per melter. The systems upstream and downstream of the melters must be capable of handling at least 2 canisters every 24 hours to maintain the two melters at their peak production rate. The availabilities of these systems when combined with the balance of the facility, including the melters, must support the net production rate of 480 canisters per year. The following reviews the peak capacities of these systems and their availability against the Contract requirement of 6MTG/day peak production rate and 480 canisters per year and the ORP Stretch Goal of 615 canisters per year.

Figure D.1 shows schematically the functions and areas involved in HLW canister handling. As shown System HRH is responsible for importing canisters into the facility – specifically to the Canister Handling Cave System (HPH) – and the HPH system is responsible for delivering the canisters to the melter for pouring and returning the canisters to the Cooling Racks for cooling. From Table D.1 the following are the total times required for these functions:

Function	Time Duration, minutes
Import from truck bay to pour tunnel bogie (Note this is the maximum. If the import bogie is busy the canister is placed in the import buffer rack. A transfer from that rack to the pour tunnel bogie takes 52 minutes. If the pour tunnel bogie is busy the canister is placed in the canister handling cave buffer rack. The time to transfer a canister from the buffer rack to the pour tunnel bogie is 23 minutes.)	150
Transfer to Pour spout	8
Transfer from Pour Bogie to Canister Cooling Rack	27

After pouring the canister remains in the pour tunnel for 9 hours before being transferred to the cooling rack. There are two bogies per melter in the pour tunnels. During the cooling time of one canister the canister in the alternate bogie for each melter is being positioned and filled. There is sufficient time during the pouring time (whether it is 24 hours or 20 hours) to let the filled canister cool for 9 hours, transfer it to the cooling rack and pick up an empty canister and position that canister for pouring under the other pour spout.

The transfer times for supplying the melters with canisters and for transferring the canisters to the cooling racks are short compared with the melter pour time. Additionally, systems HRH and HPH contain buffer racks which can store canisters waiting for filling. Accordingly, these systems have significant margin for supply of the melters for the Contract and ORP Stretch goal peak production rates.

It is estimated that a canister will have to remain in the canister cooling rack for 72 hours for the temperature to drop to the level permitting it to be welded (350 °F). Accordingly, three days of canisters will accumulate in the cooling racks before canisters can be introduced into the finishing line. At 2 canisters per day this is 6 canisters; at the stretch goal rate of 2.4 canisters per day this is 7 to 8 canisters.

Figure D.3 shows the estimated times for completion of each of the major evolutions in the canister finishing line including removal of a canister from the cooling racks through transfer to the canister export storage racks. Note that there are four major stations:

- Welding Station wherein canister glass level is measured, glass shard samples are taken and the lid is welded on.
- Rinse Bogie and Station where the canister is rinsed to remove loose contamination
- Decontamination Station where the canister is placed in a Cerium bath for decontamination and then rinsed in nitric acid and demineralized water prior to drying
- Swabbing and Monitor station where the canister contamination level and dimensions are confirmed to be within specification requirements for exporting to the export cave.

A seen from review of this figure the times in the welding and decontamination stations are the most limiting. For that reason there are two positions in these stations. On a simple conservative basis the most limiting time that a set of canisters will have to remain in a station is in the decontamination station for a total time of about 14.2 hours including transport times and time in the decontamination vessels. Since this station can accommodate 2 canisters this is equivalent to a peak production rate of ~3.4 canisters per day.

24 hrs/day x 2 canisters/14.2 hours = 3.385 canisters/day

Accordingly, this station requires 60% utilization at 2 canisters per day and 70% utilization at 2.4 canisters per day.

Review of Table D.1 shows that the facility time required to export a canister for transfer to the HLW Canister Storage Building – 5.7 hours -- is short compared with the melter productions rates of 2 to 2.4 canisters per day.

As noted above the current estimate for the availability of the HLW facility including all failures, lab availability and 15% lab rework is 72%. The estimated availability of the canister handling systems is not known. Accordingly, based on the above evaluation, the canister handling lines have sufficient capacity to meet both the Contract peak production rates and ORP Stretch Goal Rates.

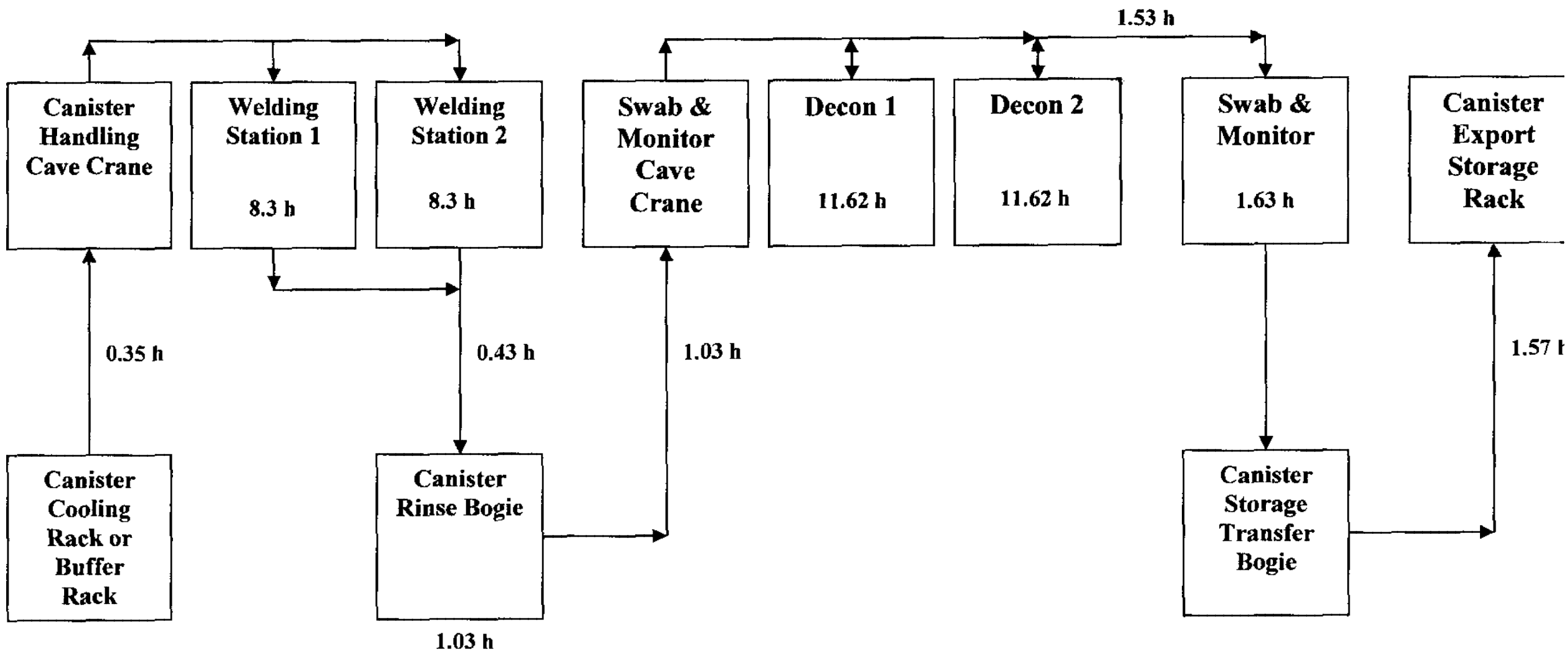

Figure D.3 Estimated Times to Complete Principal Finishing Line Functions

Redundancy and Robustness in Canister Handling Systems

Conclusion:

Redundant components have been provided in the welding station and the decontamination station to obtain acceptable utilization rates at Contract peak production rates. The decontamination station limits the throughput of the canister handling line. Rough order of magnitude assessments indicate that this station could support a peak production rate of 3.4 canisters per day; requiring 60% utilization to meet Contract requirements of 2 canisters per day and 70% utilization to meet ORP Stretch Goal peak production rate of 2.4 canisters per day.

Discussion:

See discussion above.

Identification of Single Point Failure in Canister Pouring through Finishing Line

Conclusion:

Single point failure vulnerabilities in the canister handling systems include most of the cranes, bogies and the swabbing turntable. These are not judged to be limiting with respect to canister line production since these components have very low utilization rates, MTBF long compared to their required operating times and the limiting process cycle times, (e.g., melter pour times and canister decontamination), and MTTR short compared to the process cycle times.

Discussion:

Figures D.1 and D.3 show that the single failure vulnerabilities in the canister handling systems are:

- The transfer bogies in the import, canister rinse, canister storage transfer and export tunnels,
- The cranes in the import and export bays, the canister export storage system and the canister handling and canister swab & monitor caves and
- The swabbing turntable in the canister swab & monitor cave.

There are two bogies in each pour tunnel so there is some redundancy to support melter operation during repair or maintenance of those bogies. Similarly, there are two welding heads to maintain that operation during repair or maintenance of one of those heads.

The OR Model Design Document (24590-WTP-MDD-PR-01-001, Rev5) Table 65 cites the following RAM data for some of the cranes and bogies in the canister handling system:

No. Of	Description	MTBF (hrs)	MTTR (hrs)
1*	Weld Station HPH-WELD-00004	26,298	72
1	Crane HDH-CRN-00005	9,107	96
1	Trolley HDD-TRLY-00004	52,411	72
1	Trolley HDH-RCVY-00001	87,600	72
1	Turntable HDH-TTBL-00001	4,441	96

*This table shows 1 weld station. We understand the current design contains two weld stations with two weld heads [E-mail 11/17/04, J. Pullen (BNI) to L. Demick (ORP)].

Assuming that these are representative of the other cranes and bogies in the facility, these are not expected to be limiting components for the following reasons:

- Review of Table D.1 shows that the utilization factors for these components are low compared with the process components, (e.g., melter, decontamination vessels).
- The MTBF are long compared with the operating times of these components and their utilization factors.
- The MTTR is short compared with MTBF and the cycle times of the process components.

References

1. 24590-HLW-3YD-HRH-00001, Rev 1, "System Description for HLW System (HRH) Canister Receipt Handling", Bechtel National Inc., Richland, Washington.
2. 24590-HLW-3YD-HDH-00001, Rev 0, "System Description for HLW Canister Decontamination Handling System (HDH)", Bechtel National Inc., Richland, Washington.
3. 24590-HLW-3YD-HEH-00001, Rev 0, "System Description for HLW System (HEH) Canister Export Handling", Bechtel National Inc., Richland, Washington.
4. 24590-HLW-3YD-HPH-00001, Rev 0, "System Description for HLW System (HPH) Canister Pour Handling", Bechtel National Inc., Richland, Washington.
5. 24590-WTP-MDD-01-001, Bechtel National Inc., Richland, Washington..
6. 24590-HLW-RPT-HV-03-002, Rev 3, "HLW Facility Heat Gain Assessment – Process Equipment", June 9, 2004. Bechtel National Inc., Richland, Washington.
7. 24590-HLW-M8C-C5V-00001, "HLW Pour CFD Analysis, Normal and Accident Condition", February 6, 2003, Bechtel National Inc., Richland, Washington.
8. 24590-HLW-M8C-C5V-00002, "Heat Release Data for an HLW Canister with High Conductivity Glass in a Canister Handling Rack", July 1, 2003, Bechtel National Inc., Richland, Washington.
9. 24590-HLW-M8C-C5V-00003, "Leaving Air Temperature for HLW Canister Handling Area Using High Conductivity Glass", July 1, 2003, Bechtel National Inc., Richland, Washington.
10. 24590-HLW-M8C-C5V-00004, "Peak Wall Temperatures for the Canister Handling Area using High Conductivity Glass", July 1, 2004, Bechtel National Inc., Richland, Washington.

11. 24590-HLW-M8C-C5V-00005, "Peak Wall Temperatures for the Canister Handling Buffer Storage Area using High Conductivity Glass", July 1, 2004, Bechtel National Inc., Richland, Washington.
12. 24590-HLW-M8C-C5V-00006, "HLW Heat Release Data for an HLW Canister with Low Conductivity Glass in the HLW Pour Tunnel", July 1, 2003, Bechtel National Inc., Richland, Washington.
13. 24590-HLW-M8C-C5V-00010, "HLW Pour Cave CFD Analysis" June 14, 2004, Bechtel National Inc., Richland, Washington.
14. 24590-WTP-RPT-PO-03-045, Rev 0, "Operations Research Assessment Report", Bechtel National Inc., Richland, Washington.
15. 24590-HLW-M8C-C5V-00004, "HLW C5V HVAC Equipment Sizing and Selection", Bechtel National Inc., Richland, Washington.
16. 24590-WTP-RPT-PO-03-045, "Operations Research Assessment Report", Bechtel National Inc., Richland, Washington..
17. CCN: 046869, "Step times for High Level Waste Systems Decontamination Handling and Export Handling", J. S. Leam, November 18, 2002, Bechtel National Inc., Richland, Washington..
18. 24590-WTP-MDD-PR-01-001, Rev 5, Bechtel National Inc., Richland, Washington.

AUDIT NOTES
Section E
MELTER CELL AND CANISTER LINE MAINTENANCE SYSTEMS

Introduction

The maintenance provisions for the melter cells and canister handling equipment are part of the design of equipment in these systems. The affected systems include:

- HRH – Clean Canister Import Tunnel System
- HPH – Canister Handling Cave System
- HSH – Melter Cave
- HDH – Canister Swab and Monitor Cave System
- HEH – Canister Storage and Export System

The maintenance requirements for mechanical handling equipment in these systems are specified in the "General Specification for Mechanical Handling Equipment Design and Manufacture" (24590-WTP-3PS-M000-T0002) and by specific requirements of the WTP Basis of Design (24590-WTP-DB-ENG-01-001), *Section 11, "Mechanical Basis of Design."* The objective of requirements set in these documents is to perform major equipment maintenance or repair "hands-on" and limit "remote" maintenance activities to routine tasks required to support equipment operation, (e.g., replacement of consumables such as bubblers in the melters and HEPA filter elements). The equipment and the facility are designed to facilitate and achieve this objective. The following discusses the results of the specific lines of inquiry pursued in this area.

Operator Viewing Requirements and Basis (e.g., direct, remote)

Conclusion:

The operator viewing provisions are based on providing direct viewing (leaded glass windows) at locations where the operator performs "hands-on" functions. Additionally, in-cave and out-cave closed circuit television s (CCTVs) are used to provide remote viewing of all operations conducted in the HLW Vitrification facility including operations that use direct viewing. This philosophy and approach are judged to be appropriate to establish where direct and/or remote viewing is provided for operator functions.

The scope of this oversight did not include an assessment of the full scope of viewing provisions. Based on the sample reviewed (principally in the melter cave and the pour tunnel) the philosophy was effectively implemented.

Discussion:

The operator viewing provisions in the HLW Vitrification facility include direct viewing through leaded glass windows and remote viewing using in-cave and out-cave CCTV cameras.

Direct viewing (leaded glass windows) is provided at locations where the operator performs "hands-on" functions. These functions may involve the use of cranes, Master Slave Manipulators(MSMs), and powered manipulators(PARs). For example, there are eight windows in the melter cave; seven of which are equipped with MSMs and controls for the in-cave cranes and PARs. Provisions are in place at the eighth window to install MSMs if needed in the future. Functions performed by the operator at these stations include secondary solid waste size reduction and packaging for transfer out of the cell for disposal, decontamination of equipment, tools and parts, maintenance on the melter and replacement of melter consumables, and support for major equipment replacement (e.g., melter, melter cell vessels). Similar work stations are provided throughout the facility, such as at the canister level measurement, sampling and lid welding station, canister decontaminating and swabbing station, secondary waste drum swabbing and lidding station.

A significant number of in-cave and out-cave CCTVs are used to provide remote viewing of all operations conducted in the HLW facility. The majority of the cameras are in-cave, located, for example, on walls, crane hooks, and PARs. There are cameras in the canister pour tunnel and positioned on the melter pour spout to monitor the setup of the canister for pouring, and the pouring operation itself. In areas of high temperature, (e.g., in the pour tunnel), the cameras are located out of the cave using quartz windows in the cave walls to view in-cave operations. The in-cell cameras can be removed for repair and replacement. All camera fields of view can be adjusted using pan, tilt, zoom and focus controls. IGRIP simulations used in the design process are used to confirm that the location and field of view range for each camera to provide the required coverage of each facility operation.

Identification of Remote Maintenance Requirements and their Basis (e.g., MSM, PAR, crane)

Conclusion:

The HLW Vitrification facility has been designed, and equipment has been specified, to perform hands-on maintenance of major in-cave support equipment, (e.g., cranes, bogies, PARs, MSMs, cameras). This is accomplished by providing dedicated decontamination and repair facilities for this equipment. The maintenance requirements are specified by the equipment supplier as required to meet the functional requirements and lifetime of the equipment specifications.

In-cave (or cell) maintenance of melters, filters, etc. is performed using in-cave cranes, MSMs and powered manipulators principally to replace consumables, (e.g., bubblers, filter elements). The WESP is also designed for remote replacement of the electrodes. These components are designed to facilitate the remote replacement operations.

Discussion:

The WTP Basis of Design requires in:

- Section 11.5.1, *"Material transportation systems and in-cell handling equipment shall be maintained in purpose-built maintenance facilities, after being decontaminated in a* *decontamination facility to a contamination level that will allow hands-on maintenance."* and,

- Section 11.3.2.2, *"The mechanical handling equipment shall be designed to be removable through dedicated maintenance areas. These areas shall be shielded and maintained accessible for decontamination and operator access. Provision shall be made in the layout for adequate maintenance areas to allow for the periodic replacement of mechanical equipment and components."*

Accordingly, the facility is designed to maintain and repair all major in-cave equipment by contact maintanance; no remote maintenance of this equipment is planned. Decontamination and repair facilities are provided for bogies, cranes, PARs and MSMs. Decontamination is performed in remotely operated facilities and pits. All maintenance is then performed by contact maintenance in shielded dedicated facilities. For cranes, PARs and bogies, these facilities are adjacent to the cave or tunnel in which the equipment is used. Shield doors are used to separate these maintenance facilities from the working cave. Out-cave recovery means are provided to retrieve the equipment into these facilities in the event of a major failure. Maintenance of MSMs is performed in a dedicated C3 cell.

The maintenance requirements are established by the equipment supplier to meet the life time requirements of the equipment specification. The general equipment specification (24590-WTP-3PS-M000-T0002) requires a 40 year operational life for all mechanical handling equipment. Availability of the equipment is initially established through facilitated sessions by project Systems Engineering to develop mean time to failure and maintenance and mean time to repair or perform maintenance. These data are updated as information is obtained from the equipment supplier.

The major cranes in the facility, (e.g., the melter cell main crane, handling cave overhead crane) are specified as CMAA Service Level E (Data Sheet 24590-HLW-M0D-HSH-00013, Melter 1 Cave Main Crane). This is a more severe service classification than warranted for these cranes and is used as a conservative standard.

The melter cave and the Wet Electrostatic Precipitator (WESP) cave include equipment that requires maintenance. The melter bubblers, HEME filters and some jumpers will need to be replaced periodically. Provisions are provided in the melter cell, (e.g., special racks to contain the replacement parts, waste bin to contain the replaced parts and shears to re-size the replaced parts for packaging) and the equipment is designed to facilitate removal of the old parts, replacement of the parts and packaging of the removed parts for transport out of the facility and disposal as part of the RWH system (24590-HLW-3YD-RWH-00001, Rev 1). These operations are performed by the operators using direct and remote viewing with the in-cave MSMs, PAR, crane and power manipulator.

Expected Service Duty of Remote Maintenance Equipment

Conclusion:

As noted in the preceding discussion, other than replacement of consumables, (e.g., in the melter, filters) in-cave equipment maintenance will be performed hands-on in dedicated shielded facilities after decontamination of the equipment. This includes cranes, manipulators, motors, pumps, agitators, bogies, hatches. Small equipment such as nut runners, impact wrenches, saws, shears, etc. will be replaced rather than maintained. Accordingly, this is not considered a vulnerability to facility throughput.

Discussion:

See preceding discussion

Facility Capability to Repair Maintenance Equipment

Conclusion:

As discussed earlier, major maintenance equipment consisting of cranes, MSMs and PARs have designed maintenance areas and tools to support their maintenance. Since maintenance is to be completed hands-on, the equipment to be used for that maintenance can be easily replaced as required following decontamination of the equipment.

Facility Capability to Replace Process Equipment

Conclusion:

It is possible to replace all of the major process equipment in the melter cell and the canister handling lines. Except for the melter, the equipment is designed for 40 year life and the expectation is that it will not have to be replaced. However, provisions are provided to replace, for example, the Melter Feed Preparation Vessel, the Melter Feed Vessel, the HEME vessels, if required, using the used melter transport cask and special racks designed for that purpose. The melters are designed to be replaced periodically; currently every five years. The WESP vessel is designed for the life of the facility and is not designed for remote replacement. The WESP electrodes are design for contact replacement through the top of the WESP.

Identification/Design of Special Tools for Maintenance

Conclusion:

There are few special tools identified for remote maintenance of equipment. Major equipment and maintenance and repair or replacement is performed hands-on in dedicated shielded facilities. Special features are provided for decontamination water spray and CO_2 spray wands to facilitate equipment decontamination. Where in-cave replacement of consumables or recovery of failed equipment is required, special features are provided in the design of the affected equipment to facilitate these actions.

Discussion:

As noted the equipment requiring in-cave maintenance, (e.g., for replacement of consumables) is designed to facilitate completing that maintenance using the operator remote handling equipment, (e.g. MSMs, PARS, and cranes).

Other maintenance of major equipment is performed in dedicated facilities after decontamination. There are jigs and templates that are used to support equipment during decontamination prior to transfer to the dedicated facilities for "hands-on" maintenance. Dedicated systems are provided for decontamination using water, CO_2 or steam sprays (24590-HLW-M0D-30-00266 and 00267).

Based on discussions with BNI personnel, special features are also provided on all transport equipment (e.g., bogies, doors, hatches and cranes) to either place them in a "safe" position and/or move them to the dedicated maintenance facility for replacement or repair. For example:

- Shield doors can be remotely opened or closed using manual operators outside the cave in the event of a door motor failure.
- "Dead men" cables are provided to retrieve bogies into maintenance cells in the event of a transfer motor failure.
- The pour tunnel bogies are positioned with push-pull chain drives that can be operated manually to bring the bogie into the maintenance facility.
- Hatches are equipped with bales that facilitate use of the cave crane to open or close the hatch and remove it from the cave for replacement, maintenance or repair.

References

1. 24590-WTP-DB-ENG-01-001, Rev 1B, "WTP Basis of Design", June 3, 2004, Bechtel National, Inc., Richland Washington.
2. 24590-WTP-3PS-M000-T00002, Rev 2., "General Specification for Mechanical Handling Equipment Design and Manufacture", May 10, 2004, Bechtel National, Inc., Richland Washington.
3. 24590-HLW-3YD-HRH-00001, Rev 0, "System Description for HLW System HRH Canister Receipt Handling", October 15, 2003, Bechtel National, Inc., Richland Washington.
4. 24590-HLW-3YD-HPH-00001, Rev 0, "System Description for HLW System HPH Canister Pour Handling", December 12, 2003, Bechtel National, Inc., Richland Washington.
5. 24590-HLW-3YD-HSH-00001, Rev 0, "System Description for HLW Melter Cave", Bechtel National, Inc., Richland Washington.

6. 24590-HLW-3YD-HPH-00001, Rev 0, "System Description for HLW Canister Decontamination Handling System (HDH)" *Draft,* Bechtel National, Inc., Richland Washington.
7. 24590-HLW-3YD-HSH-00001, Rev 0, "System Description for HLW System HEH Canister Export Handling", October 30, 2003, Bechtel National, Inc., Richland Washington.
8. 24590-HLW-M0D-30-00266 & 00267, "Mechanical Handling Data Sheet, Liquid Pressure Washing Supply System, Portable Unit 01",

AUDIT NOTES
Section F
HOT CELL SOLID WASTE MANAGEMENT SYSTEMS

Introduction

The HLW Vitrification facility has two major systems for the management of in cave equipment wastes, these are the:

- Radioactive Solid Waste Handling System (24590-HLW-3YD-RWH-00001) is designed to perform the packaging and transport of smaller secondary solid waste generated from melter cave equipment maintenance and facility HEPA filter changeout. This waste is packaged in 55 gallon drums and transported from the facility in transport casks for disposal by DOE. Secondary solid waste is comprised of HLW system consumables, (e.g., bubblers, filters, thermowells), replaced jumpers, small in-cave equipment (e.g., saws, nut runners, impact wrenches), waste materials used in the course of operation. Secondary solid waste is handled and packaged for transport out-cave in both melter cells and in the HEPA filter cave. Secondary solid waste is separated, size reduced, if required, placed in waste baskets and transferred into 55 gallon drums for transport out of the facility for disposal.

- Melter Transport System (24590-HLW-3YD-HMH-00001) is designed for the installation and removal of large equipment components (e.g., melter, melter feed preparation and feed vessel and submerged bed scrubber) from the melter caves. This system uses a specially designed overpack which mates to the melter cave access door which provides a radiation shielding and controlled ventilation air flow access door.

The following discusses the results of the specific lines of inquiry pursued in this area.

Identification of Solid Waste Types and Quantity

The projections of solids waste type and volume for the HLW Vitrification Facility are preliminary. The major source of waste from the facility will be:

- HEPA filters packages as low-level waste in 55 gallon drums
- Melter cave consumables contaminated with glass (e.g bubbler assemblies, dip legs) and packaged as TRU waste in 55 gallon drums.
- Melter cave consumables not contaminated with glass (e.g bubbler assemblies, dip legs) and packaged as low-level waste in 55 gallon drums.
- Large equipment components (e.g. spent melters, and potentially vessels) infrequently removed in the HMH system.

Capability for Temporary Storage of Solid Waste

Conclusion:

There is adequate temporary storage provided for solid waste that is likely to be generated during normal plant operation. This includes permanent waste bins and the waste baskets that are filled to transport the waste out of the caves as well as lay down space on false flooring and grates for larger components that require re-sizing prior to packaging for disposal.

Discussion:

There is a waste bin in each melter cave that is used to store bubblers, RTDs and other components that are replaced periodically on the melter. The material is periodically removed from the waste bins and either placed directly into waste baskets in the cave or size reduced using equipment in the cave so that it will fit in the waste baskets.

HEME filter replacement is performed in the melter cave as required and the replaced filters are placed in the waste baskets for disposal.

Similar operations are performed in the HEPA filter cave for disposal of the filters replaced in the HEPA filters.

Other small components that may need to be replaced in the HLW facility, (e.g., jumpers) are transported to the melter cave (if required), size reduced (if required) and placed in the waste baskets for disposal. The same process is followed for small tools, (e.g., saws, nut runners, impact wrenches).

Larger jumpers or other components that require use of saws or plasma torch for re-sizing for packaging are transported to the false floor or grating in the melter caves for the re-sizing operations.

Time Dependency for Solid Waste Ship out

Conclusion:

It is judged that the radioactive sold waste system is adequate to receive and dispose of solid waste generated in the facility and managed in the RSW and HMH systems without impacting glass production rate.

Discussion:

The re-sizing of components for disposal and filling of the waste baskets for transport out of the melter or filter caves is an occasional manual operation performed by the cave operators using MSMs, PARs, and power manipulators. No specific timeline has been established for these operations; these are performed on an as-required basis.

The transport of the waste baskets out of the caves, containing them and sealing them in 55 gallon drums and transporting and placing those drums in the transport cask for disposal are the functions of the RWH system. The baskets are lowered through hatches in the melter or filter caves into 55 gallon drums located in a drum transfer tunnel under the caves. The drums are transported to a swabbing/monitoring area that is used to place and secure the lid on the drum and confirm that the drum contamination levels are acceptable for transport out of the facility. This station has swabbing, radiation field monitoring and decontamination facilities. Once the drum has been confirmed to have acceptable radiation and contamination levels it is transported to the cask import/export area and loaded into the transport cask. The transport cask is then loaded onto a trailer for transport to the disposal area.

A specific timeline has not been developed for these operations because there can be significant variability in the packaging, swabbing, monitoring and de-contaminating activities. The RWH system operates in parallel with and separately from glass production operations. It is judged that the time required to complete these operations will be adequate to ensure that secondary solid waste can be removed from the caves and disposed of without impacting glass production rate.

The removal of large failed equipment (e.g. melter, vessel) in the HMH system is infrequent (~once per 5 years) and results in shutdown of the facility.

Approach and Capability for Size Reduction

Conclusion:

Sufficient means are provided to perform necessary size reductions of components and equipment that will or may require replacement during normal plant operation.

Discussion:

Size reduction of solid waste is performed in the melter caves. The filters from the HEPA cave are placed separately in the waste baskets and do not require size reduction (This statement is based on meeting discussions with BNI personnel. The RWH system description states that the filters are to be compacted. The system description is being updated.)

The following equipment is provided in the melter caves for size reducing other components, based on meeting discussions with BNI personnel.

- A power shear capable of handling smaller components such as melter bubblers, RTDs, small jumpers, etc.
- A plasma torch is provided for cutting larger jumpers, plates, racks, WESP electrodes, etc.
- A chop saw is provided for miscellaneous cutting

The shear is a relatively "clean" operation and it is located near an operator window in the upper part of the cave.

The plasma torch and saw are located on a grating in a lower part of the cell. The grating is supplied with a separate downdraft ventilation system that is used to contain and filter out debris generated during use of the plasma torch and saws.

Identification/Design of Special Tools/Package Requirements and status of design/acceptance

Conclusion:

Many special tools and handling devices have been designed to facilitate required remote manual operations in the HLW facility, (e.g., equipment decontamination, solid waste re-sizing and packaging for disposal). However, operating experience in remote facilities shows that there will be a continuing revision to and addition of special tooling to facilitate remote manual operations throughout cold and hot commissioning and operation of the plant. Personnel skilled in the design of these tools will be required to support plant operation.

Discussion:

Standard tooling modified or adapted for remote handling is used for size reduction, drum sealing and swabbing and decontamination. The modifications and adaptations involve for example, adding bales and extensions to facilitate handling using MSMs and cranes, providing simple and remotely operable means for changing blades in saws, use of standard fastener sizes so sockets on nut runners and impact wrenches do not require frequent change out.

Mechanical functional diagrams have been developed for each phase of the solid waste handling system. IGRIP simulations of the layout and operation of in-cave equipment and CCTVs are used to ensure that the operator has sufficient field of vision and scope of travel with the MSMs, power manipulators, PARs and cranes to handle the equipment remotely and perform the required functions for solid waste packaging and transport for disposal.

The drums are swabbed and monitored prior to export to the transfer cask to ensure that contamination and radiation limits conform to applicable ALARA principles and criteria. With respect to contamination the drum exterior contamination levels must permit transfer from a C3 to C2 area. The radiation levels must be consistent with the shielding characteristics of the transport cask to meet the Dose Equivalent Rate Criteria for transport to the disposal site.

Strategy for Removal/Packaging of Large Failed Equipment from Melter Cave and Canister Finishing Line

Conclusion:

Sufficient means are provided for removal and packaging of large failed equipment from the melter cell, e.g., feed preparation and feed vessels, HEME vessels, and the canister finishing line, e.g., cranes, bogies.

Discussion:

The melter cave is designed for periodic removal and replacement of the melter using the MHM system and cask. This same system can be used to remove and replace several of the vessels in the melter cave. [HSH System Description – to be prepared in early 2005]. These include:

- Melter Feed Preparation Vessel
- Melter Feed Vessel
- HEME Vessels

Racks and lifting and tilting rigs are stored in the lower section of the melter cave for this purpose. To remove a vessel from the cave after disconnecting all attached jumpers, it is raised and then lowered on its side onto its cradle. The cradle is positioned on the rails used to transport a used melter into the buffer area and then into the used melter transport cask. The replacement vessel is similarly transported into the airlock and then into the cave for installation. (Note that these vessels are designed for a 40 year life. This capability is provided as a contingency.)

The cranes and bogies used in the canister finishing lines are provided with dedicated facilities for decontamination and hands-on maintenance and repair. These could be replaced in total if required in these facilities. It is more likely that failed components, (e.g., motors, position sensing switches), would be replaced to maintain that equipment in service. If needed other failed components, (e.g., hatches, racks) could be lifted into the melter caves through removal plates in the floor of the caves for size reducing and disposal using the RWH system.

References

1. 24590-HLW-3YD-RWH-00001, Rev 1, , "System Description for High Level Waste Vitrification Facility Radioactive Solid Waste Handling System", November 25, 2003, Bechtel National, Inc., Richland Washington.

2. 24590-HLW-3YD-HMH-00001, Rev 1, , "System Description for System HMH High Level Waste Melter Transport System", January 14, 2004, Bechtel National, Inc., Richland Washington.