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United States Government | Department of Energy

memorandum

Richland Operations Office

DATE: AUG 1, 2003

REPLY TO ATTN OF: WEC:WFH 03-WEC-036

SUBJECT: DESIGN OVERSIGHT REPORT – "LOW ACTIVITY WASTE (LAW) MELTER SUPPORT SYSTEM CAPACITIES," D-03-DESIGN-002

TO: William J. Taylor, Assistant Manager for Waste Treatment and Immobilization Plant

This memo transmits the attached Design Oversight Report, "LAW Melter Support System Capacities," D-03-Design-002, completed June 30, 2003. This report summarizes a technical review of the design capacity of LAW Melter Support systems, to determine the peak treatment capacities of the major support systems, including feed preparation/glass formers, off-gas, HVAC/cooling, mechanical handling, electrical/utilities, and sampling. This review utilized current design data and engineering judgment to determine peak capacities of the selected LAW systems under optimum operating conditions. The Waste Treatment and Immobilization Plant detailed design is currently ongoing, so exact capacities are still being developed and refined.

This report has concluded that the Bechtel National, Inc. design of these support systems satisfies the Contract requirements regarding LAW Facility capacity at the Cold Commissioning "expected rate" of five days at an average of 32 metric tons of glass per day (MTG/D). Based on the current state of design, the mechanical handling systems and the HVAC/cooling systems are the most limiting systems for the design capacity. Specifically, the factors that limit the maximum treatment capacity of the LAW vitrification facility are the maximum allowable temperature of the container lifting flange for removal from the pour cave, the cooling capacity in the container finishing line and/or buffer store, and the container load-out bay cycle time. The other support systems have designs that would limit LAW Facility peak treatment capacities to the range of 40 to 50 MTG/D peak.

If you have any questions, please contact me, or your staff may contact John Orchard, WTP Engineering and Commissioning Division, (509) 373-0405.

William F. Hamel, Director
WTP Engineering &
Commissioning Division

Attachment

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

Waste Treatment Plant
LAW Melter
Support System Capacities

D-03-DESIGN-002

June 2003

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Executive Summary

Office of River Protection (ORP) staff and technical contractor support staff have conducted a Technical Design Oversight of the design capacities of the Waste Treatment and Immobilization Plant (WTP) Low Activity Waste (LAW) facility systems. The principal objectives of this oversight were to: (1) Establish the maximum treatment rate of the LAW vitrification facility that could be supported by the current design capacities of the LAW process and facility support systems, including the balance of facilities, and (2) Identify the factors that limit the maximum treatment rate of the LAW vitrification facility. The estimated peak glass production capability of the LAW facility was then compared (1) with baseline Contract production rate requirements to confirm that they are met with the current design, and (2) with DOE-ORP stretched LAW glass production goals to determine if these goals could be met. Where the estimated production rate did not meet the stretch targets, actions that could be taken to increase the rates to levels that would meet the stretch goals were identified.

The results of the estimate of the impact of each area of the LAW facility reviewed on the peak glass production rate of the facility are summarized in Figure i (Figure 1 in the report). This figure shows the peak production rate that could be supported by the identified area or system independent of the rest of the LAW facility capabilities. This figure shows that the most limiting area of the facility is the time that is required to transfer canisters from the facility airlock to DOE for burial. This limits production to 32 MTG/day. This is acceptable to meet baseline Contract requirements, which are equivalent to a peak production rate of 24 MTG/day minimum and 32 MTG/day expected. This rate does not meet the target goal of the Contract of 36 MTG/day nor the stretch DOE-ORP target goal of 40 MTG/day. It should be noted that the plan for transfer of the canisters to DOE has not been finalized for the current design of the facility. Data from original facility analyses were used to establish the time for this evaluation. It is believed that relatively straightforward changes could be made to reduce the time required for export of canisters to DOE, and support a production rate at the DOE-ORP target goal.

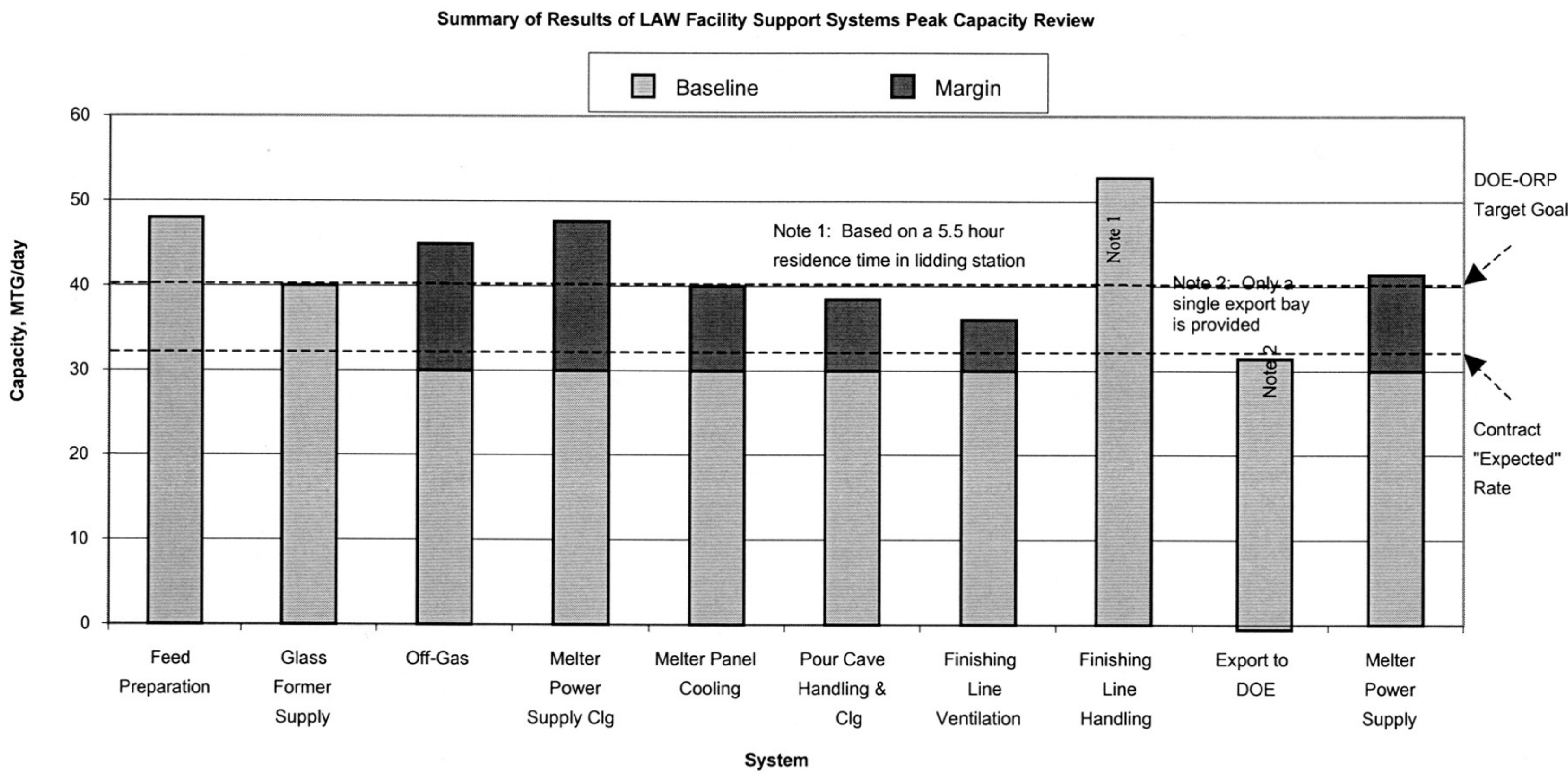
Estimates for limiting conditions of operation for other areas of the facility indicate that the Contract goal of 36 MTG/day could be met for the current design of the facility other than the export bay (as discussed above). However, the capacities of the ventilation and cooling systems do not support the DOE-ORP stretch target goal of 40 MTG/day. The BNI analyses that were used as the bases for these estimates are conservative. The design of these systems is also not complete. It is possible that once conservatisms in the design analyses for these systems are reduced, and the system designs are complete that the systems may support the DOE-ORP stretch target production rate.

Table 1 of the report summarizes actions that could be taken to improve the potential that the final LAW facility design will support the DOE-ORP stretch target production rate. These actions do not have impact on the Contract with BNI. DOE-ORP should review the actions identified in Table 1 and evaluate which should be pursued.

At the time of this review the design of the LAW facility was being revised to account for the change in the baseline from three LAW melters to two LAW melters. The conclusions reached in this review are based on work in progress, discussions with BNI design personnel, review of the design margins applied in the three melter design and application of margins as defined in the BNI design criteria. The results of this review are conservative and may change once the final design of the LAW facility is completed.

As stated above, no open issues were identified in this review. The review concludes that the current design of the LAW melter support systems and other systems involved in the production of LAW glass are sufficient to meet baseline Contract requirements. Accordingly, this report will not be submitted to BNI and will be retained as an internal AMWTP report.

Figure i


Summary of Results of LAW Facility Support Systems Peak Capacity Review
Baseline
Margin
Capacity, MTG/day
0
10
20
30
40
50
60
Note 1: Based on a 5.5 hour residence time in lidding station
Note 1
Note 2: Only a single export bay is provided
Note 2
DOE-ORP Target Goal
Contract "Expected" Rate
Feed Preparation
Glass Former Supply
Off-Gas
Melter Power Supply Clg
Melter Panel Cooling
Pour Cave Handling & Clg
Finishing Line Ventilation
Finishing Line Handling
Export to DOE
Melter Power Supply
System

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1.0 INTRODUCTION

A Team comprised of personnel from the ORP WTP Engineering and Commissioning Division and support consultants performed a technical oversight of the support systems for the LAW Facility melters. The purpose of this review was to develop a reasonable estimate of the maximum achievable production rate of the LAW facility (e.g., MT glass per day) independent of the capabilities of the melter itself.

The oversight included review of applicable documentation and discussions with BNI Process and Mechanical Engineering personnel and management as summarized in the Oversight Plan [1]1.

2.0 BACKGROUND

WTP Contract Requirements

The purpose of this review was to identify the factors that constrain the maximum waste treatment rates of the WTP LAW facility independent of the capability of the LAW melter to produce glass. The WTP Contract [2] requires that the LAW facility have a baseline minimum average waste treatment rate of 733 Na units/year. The Contract also requires that the facility capacity be expandable to satisfy a treatment rate goal of 1,100 Na units per year. For the bulk of LAW to be treated, the minimum required average waste treatment rate is approximately equivalent to an average glass production rate of 20 MTG/day at a glass waste loading of 14 wt%. The Contract also specifies LAW glass and Na treatment rate requirements during cold commissioning of the facility that range from 24 MTG/day to 36 MTG/day. The specified Na treatment rates during hot commissioning are bounded by those specified for cold commissioning. The cold and hot commissioning rates will be demonstrated over relatively short periods of time (5 to 20 days during cold commissioning and up to 63 days during hot commissioning) and should, therefore, be representative of the peak glass production rate of the facility.

The peak LAW glass production rate that must be achieved during commissioning to meet minimum Contract requirements is 24 MTG/day. At this peak production rate, however, the facility would have to have an availability of 83% in order to achieve the average production rate of 20 MTG/day that is required to meet the 733 Na units/year waste treatment requirement. The current availability estimates for this facility are still under development, but in analyses performed to date have varied from a low of 63% to the current 77% [3, 4]. The BNI design efforts have assumed that the LAW facility will have a baseline peak glass production rate of 15 MTG/day per melter or 30 MTG/day for the facility. It is noted that this would require a facility availability of 67% to meet the minimum required average Na treatment rate, but greater than 100% availability to meet the Contract goal. For the purposes of this evaluation, it will be assumed that an estimated facility peak production rate of 30 MTG/day will meet the minimum Contract requirements for LAW treatment.

DOE-ORP Extended LAW Production Target Goals

The Department of Energy Office of River Protection (DOE-ORP) has cited stretch goals for increased capacity of the Waste Treatment and Immobilization Plant (WTP) that would reduce the overall time for treatment of the tank wastes [5]. These stretch goals increase the base for the current LAW facility configuration of two melters to an equivalent peak production rate of 36 MTG/day at an availability (Total Operating Efficiency, TOE) of 80% and a glass waste loading of 14 wt% Na_2O. DOE-ORP has also a stretch Target goal for the facility which calls for a peak production rate of 40 MTG/day, TOE of 85% and a glass loading of 20 wt% Na_2O.

1 Numbers in brackets refer to references listed in Section 6.0, below.

The analysis discussed herein establishes the peak production rate of the LAW facility based on the current status of the design of the facility and identifies and ranks those factors in the current LAW facility design that limit the peak production rate. This analysis also compares those limits with the DOE-ORP stretch goals for the production rate of this facility and where the estimated rate does not meet these goals identifies actions that could be taken to meet the goals.

At the time of this evaluation the design of the LAW facility was not complete. Accordingly, the conclusions of this evaluation represent a snapshot of the design in time and could change as the design evolves. This evaluation also does not include estimates of availabilities or attempt to establish an expected long term average production rate of the facility. The maturity of the design and the RAMI analyses do not support such an evaluation at this time.

3.0 OBJECTIVES, SCOPE, AND APPROACH

3.1 Objectives

The following are the specific objectives of this oversight:

1. Establish the maximum treatment rate of the LAW vitrification facility that could be supported by the current design capacities of the LAW process and facility support systems, including the balance of facilities. Confirm that this rate is sufficient to meet WTP Contract requirements.

2. Identify the factors that limit the maximum treatment rate of the LAW vitrification facility.

3. Scope actions that could be taken to increase the capacities of systems that limit the overall LAW peak production rate below DOE-ORP stretch goals.

3.2 Scope

This oversight included review of the design capacities and margins for melter feed preparation, off-gas, plant cooling water, chilled water, electrical supply, material handling, sampling, and Balance of Facility interfaces. The specific products reviewed and the depth of the reviews are summarized in Appendices A and B to this report.

3.3 Approach

The approach to this oversight included the following effort:

- Examined the bases for the design capacities and margins in the LAW melter and facility support systems.

- Reviewed the limiting conditions of operation for the LAW facility with respect to production of LAW glass at nameplate capacity independent of the melter capacity.

3.3.1 Preparation

1. Identified the BNI and ORP Points of Contact for this review and discussed the plan for this oversight with BNI management and affected personnel.

2. Identified the LAW process and facility SSCs and other factors that affect the treatment rate of the facility.

3. Collected documentation, e.g., flow sheets, PFDs, calculations, system descriptions, OR model inputs, BNI design criteria that characterize the capabilities of the LAW facility and establish design margins in these systems.

3.3.2 Review and identify, resolve or document issues

Reviewed the collected documentation, evaluated the selected attributes and developed lines of inquiry and specific questions that were explored with cognizant BNI personnel to meet the oversight objectives. The results of these reviews are documented in the summary tables of Appendix A and Appendix B. This effort included periodic meetings with cognizant BNI personnel to discuss ORP questions and lines of inquiry and BNI responses to these. Summary reports of these meetings are also included in Appendix B. Specific design data collected as part of this effort to establish design margins are documented in Appendices A and B.

3.3.3 Reporting

Prepared a draft report that summarized the activities, the results, conclusions and recommendations of the review. The draft report was submitted to ORP management for review. The conclusions of the draft report were reviewed with cognizant BNI personnel on June 13, 2003. This final report resolves comments received from ORP management on the draft report and incorporates comments received from BNI on the conclusions of the review in the meeting of June 13, 2003.

Note that since this review did not identify any open issues with the capabilities of the LAW facility to meet Contract requirements, this report will not be submitted to BNI but will be retained as an internal ORP AMWTP document.

4.0 RESULTS

4.1 Objective 1

Establish the maximum treatment rate of the LAW vitrification facility that could be supported by the current design capacities of the LAW process and facility support systems, including the balance of facilities.

Note: Appendix A to this report summarizes the bases for the following discussion. Appendix B summarizes the lines of technical inquiry explored and the responses received from BNI to these lines of inquiry as part of this design oversight. The following summarizes the key results of the oversight relative to this objective as well as the other technical objectives discussed in subsequent sections of this report.

4.1.1 Figure 1 summarizes the results of the review of design capacities of the LAW melter and facility support systems. The bar chart shows the capability of each area reviewed in terms of the limit that area imposes on the peak glass production rate of the facility in metric tons of glass per day, independent of the balance of the LAW facility. The lighter area of each bar terminates at a glass production rate that is consistent with the baseline design capability of the area. In general, BNI is designing for a peak production rate of 15 MTG/day for each melter or 30 MTG/day for the facility. The darker areas of Figure 1 show estimated margin in the capacities of the reviewed systems.

Review of Figure 1, when considering baseline capacity and margin, shows that the maximum achievable production rate of glass for the current design of the facility is limited to 32 MTG/day; the current peak rate at which canisters are transferred from the facility to DOE. It should be noted that this rate is based on the original facility design and that the process for delivery to DOE in the current design has not been developed. It is believed that this rate can be readily increased such that this does not limit the production rate of the facility.

4.1.2 The next more limiting areas include the pour cave and finishing line cooling and ventilation systems. The pour cave and finishing line cooling systems capacities limit these areas to a peak production rate of about 38 MTG/day. This limit may be improved once the glass thermodynamic properties are established and used in re-evaluation of the pour cave and finishing line temperatures.

4.1.3 The results of the evaluation show that the facility most limiting peak production rates exceed the rate that is required to meet Contract baseline production rates. At a peak production rate of 30 MTG/day a facility availability of about 0.66 is required to achieve the Contract treatment rate of 733 units of Na per year (assuming Envelope A and 14 wt% Na_2O). The current estimate of availability for the LAW facility is 0.77 assuming a 16 week bubbler lifetime. The review concluded, therefore, that there were no system constraints on operating the facility at a rate consistent with Contract requirements. Note that in some cases this oversight review concluded that the baseline design capability exceeds the baseline rate of 30 MTG/day and the Contract expected rate of 32 MTG/day (shown as a dotted line on the figure).

4.1.4 The results do not support a LAW facility peak production rate of 40 MTG/day; the DOE-ORP stretch target goal for this facility. The discussions in the next section characterize the nature of the limits on production for each area reviewed, and Table 1 summarizes action that could be taken to resolve these limits and improve the potential for meeting the stretch target peak production rate.

4.2 Objective 2

Identify the most limiting conditions of operation for the LAW melter and facility support systems.

4.2.1 The following summarizes the bases for the estimates of the limiting conditions of operation for each of the areas shown in Figure 1. Appendix A provides more detailed descriptions of these bases.

Feed Preparation

There are several factors that can influence the peak capacity of the feed preparation system (independent of the glass former feed system which is discussed next). These factors include the concentration of Na in the feed, the required concentration of Na_2O in the glass, the time it takes to sample the feed and confirm it is acceptable, the volumes of the feed preparation and transfer vessels and the capacity of the feed transfer pumps. For the current configuration of the feed preparation system the most limiting factor is the capacity of the melter feed system. Based on Duratek data, the maximum feed rate to each melter is 480 gallons per hour. The normal feed rate when producing 15 MTG/day is between 180 gph and 300 gph based on BNI research and technology data from the pilot melter and the Duratek melter system description. The capacities of the feed preparation vessels and transfer pumps and the current timeline for the waste compliance strategy will support feeding the melter at the maximum rate of 480 gph. Based on the more conservative value of 15 MTG/day at a feed rate of 300 gph this maximum feed rate would support a peak glass production rate of 24 MTG/day per melter or 48 MTG/day for the facility. Accordingly, the feed preparation system is not limiting facility production relative to the Contract requirements or the DOE-ORP stretch target goal of 40 MTG/day.

Balance of Facility including Glass Former Feed

The current interface agreements with the Balance of Facility include margin to the required values to support the baseline and increased facility capacity as identified for each area evaluated herein.

With respect to the glass former supply system, the design capacity of this system is documented as 33.5 MTG/day. Discussions with BNI personnel indicate that the time allotted for glass former feed and mixing (i.e., 4 hours in the current timeline) is very conservative and that the glass former feed system should not be considered a limiting factor in glass production. Accordingly, it has been assumed that the glass former system can support the target peak glass production rate of 40 MTG/day.

Off-gas system

Because the LAW offgas system is largely unspecified, its capacity to accommodate higher melting rates cannot be analyzed with confidence at this point in time. BNI intends to award design-build subcontracts to vendors who must warranty the performance of the provided equipment. Thus it is likely the equipment will be conservatively designed, affording margin for higher glass processing rates. It is doubtful the margin will be 100% for destroying NOX, although the margin for other offgas processing units appears likely to be in the 100% range. The SCR margin may allow for 50% higher glass processing rates, and design changes that could increase the capacity by 100% appear feasible. For purposes of this rough analysis, it should be assumed the offgas system will allow a 50% increase in glass-processing rates, but probably not higher unless changes are made to the SCR system. Increasing the melting rate will result in increases in rates of waste recycle from the LAW melter offgas system to PT and ETF/LERF. These impacts are outside the scope of this analysis, but may be significant.

Melter power supply cooling

The melter power supplies are currently specified for a continuous rating of 1430 kW. Based on pilot melter test data and bounding estimates of the power required to accommodate melter conduction and ventilation heat losses, this continuous rating would support a melter glass production rate of 20.7 MTG/day or 41.4 MTG/day. The cooling systems for the melter power supplies are being redesigned to accommodate the change from three to two melters so actual system design data is not available. Assuming that the 15 % margin that is specified in the BNI design criteria for HVAC systems is applied to this system, the cooling systems would be capable of supporting a glass production rate of 1.15 x 41.4 or 47.6 MTG/day. This cooling system design is, therefore, not limiting and supports Contract and DOE-ORP target goals.

Melter panel cooling

For the same melter configuration and melt temperature, the melter cooling panel heat load is not a strong function of the glass production rate. However, if the increase in melter glass production rate is the result of increasing the melter area by reducing the refractory thickness, and increasing the glass temperature, as discussed by Duratek, the cooling requirement would increase accordingly. Based on data provided in the Duratek System Description, the combination of these two changes in the melter could increase the cooling panel heat load by up to 48.7%.

The cooling panels are supplied with demineralized water in a closed loop system. The demineralized water is cooled by a plate and frame heat exchanger that is supplied with plant cooling water from the balance of facility. Based on current data the heat load margins in this system are in the range of 32%. Assuming that all the criteria for cooling the melter panels remain the same, it would not be possible to accommodate the full throughput increase that would be possible for the glass melt temperature and refractory thickness changes proposed by Duratek. Assuming the effects are linear about 65% of the throughput increase could be accommodated. According to Duratek the proposed changes could result in a 50% increase in throughput. The margins in the melter cooling panel cooling system may limit that increase to 32.5% or 10 MTG/day. This would, however, support the DOE-ORP target goal of 40 MTG/day.

Pour Cave Handling and Cooling

The pour cave is cooled by a combination of forced air ventilation and strategically placed cooling panels supplied by a closed loop demineralized water system with a plate and frame heat exchanger heat sink cooled by Plant Cooling Water supplied from the Balance of Facility. The system is designed to ensure that the pour cave structure, ambient air and leaving air temperatures are maintained below limits. The system requirements were determined using the results of Computational Fluid Dynamic (CFD) calculations performed by Bechtel, San Francisco. The most limiting conditions examined in the calculations assume that a canister spends a total of 28 hours in the pour cave from the start of the initial pour to the time it is exported to the transfer tunnel. The results of these calculations show that the current cooling panel and ventilation system design conditions maintain the temperatures below limits. However, the calculations also show that after 28 hours the canister skin temperature exceeds the maximum handling temperature, and that an additional 2 hours of residence time is required to reduce the canister temperature to the level required to transfer it out of the pour cave. This constrains the minimum pour time and the glass production rate from each pour cave, and requires operating the melter pour caves in the alternating pour mode, to achieve the peak production rate. For a minimum number of pour cave carousel moves, a 30 hour pour cave residence time translates to a 7.5 hour pour time and a peak production rate of 6.4 canisters or 38.4 MTG per day for all four pour caves operating in the alternating mode.

The assumptions on the thermodynamic properties of the glass have a significant effect on the results of the CFD calculations. There are no data on the thermodynamic properties of the LAW glass so bounding properties were used in the calculations performed to date. Testing of LAW glass properties is to be completed in late summer 2003. Once the results of these tests are complete the analyses will be redone. If the LAW glass properties are more favorable than those used in the current analyses the revised analyses may support a higher glass production rate closer to the DOE-ORP target goal.

Finishing Line Ventilation

The finishing line is cooled by forced air circulation. The ventilation requirements were also determined by the CFD calculations performed by Bechtel, San Francisco. These calculations assumed that a canister was resident in each stage of the finishing line and that the canister would enter the line at least 48 hours after the start of the initial pour. This time delay is required to reduce the heat release rate from the canister to the level that can be accommodated by the finishing line ventilation system. It is also the time required to reduce the skin temperature of the canister to the level required for seal welding the lid. The finishing line ventilation calculations were performed assuming a canister enters the line every 8 hours. On this basis the finishing line ventilation system could support a glass production rate of 36 MTG/day.

As stated above, the CFD calculations that support the sizing of the finishing line ventilation system will be redone once the actual thermodynamic properties of the glass are determined. The revision to the calculations may support of higher throughput in the finishing line.

Finishing Line Handling

For the current baseline design timeline, the most limiting residence time in the finishing line is 5.5 hours in the lidding/welding station. If the pour caves could support a pour time of 5.5 hours and the canister temperatures were not limits on export of the canister from the pour caves and within the finishing line, the two finishing lines could support a peak production rate of 8.8 canisters per day or 52.8 MTG/day. Although this rate exceeds that currently assumed for the finishing line ventilation calculations, the finishing line likely could accommodate this higher production rate, but only after a longer cooling time to reduce the heat release rates from the canisters to lower values than currently assumed in the ventilation calculations.

Buffer Area

If higher than current baseline glass production rates are to be achieved in the LAW facility, it may be necessary to delay entry of a canister into the finishing line after it is removed from the pour cave to reduce its heat release rate to a value that can be accommodated by the finishing line ventilation system. The only place in the current design of the LAW facility where a significant number of canisters could reside while cooling after leaving the pour caves is in the buffer area. From discussion with BNI, it is understood that the buffer area was not included in the facility as a location for cooling the canisters. BNI indicates on a scoping basis that the ventilation system in the buffer area could accommodate in the order of five canisters if they were removed from the pour caves within 25 hours of the initial pour. This might be adequate to achieve a pour time that meets the DOE-ORP target peak production rate of 40 MTG/day. This is beyond the current baseline design of the facility, however. The current BNI timeline assumes a pour cave residence time of 48 hours (10 hours pour position, 20 hours cooling position and 18 hours export position) so the canister can enter the finishing line directly from the pour cave. The ten hour pour time is adequate to meet Contract LAW glass production rates.

Export to DOE

The process and timeline for transfer of the LAW canisters to DOE for burial has not been finalized for the current LAW facility design. For the original design, this process included 4.5 hours to clear a canister for shipment to DOE from the time it leaves the facility airlock. There is only one export facility with one truck and crane bay. This translates to 5-1/3 canisters or 32 MTG/day. This is the most limiting capacity in the LAW facility based on the current information available. It is considered that steps could be taken to revise the administrative parts of the export process tto reduce the transfer time to levels that would support the DOE-ORP target. This should be considered in the final development of the transfer process.

Electrical System/Melter Power Supplies

The facility electrical supply system is conservatively designed and is not limiting. As noted above in the discussion of the Melter Power Supply Cooling System, the power supplies are designed for a continuous rating that will support a facility peak glass production rate of 41.4 MTG/day. The power supplies are, therefore, not limiting facility production and are adequate to support Contract and DOE-ORP glass production target rates.

4.2.2 The following factors affect the conclusions summarized above for each system.

1. The rates shown are peak production rates. The average production rates would include the availability of each area which has not been considered in these discussions.

2. The design of the systems considered in this review are not complete. The margins identified in the designs are based on review of typical margins applied by BNI in the design process and discussions with the BNI design engineers. The conclusions drawn in this evaluation could change after the designs are complete.

3. The CFD calculations that set the requirements for pour cave and finishing line cooling used conservative values for air flowrates and the number of cooling panels. The most significant area of conservatism, however, may be in the glass thermodynamic properties. "Bounding" values were used. The potential impact of these conservatisms have not been considered in evaluating the limiting conditions of operation for these systems. Tests will be run in the summer 2003 to establish the actual glass properties. Once the results of the tests are available, the evaluations will be rerun to determine actual margins.

4. It is understood that it is not possible to increase the size of the ventilation system within the current footprint and configuration of the facility without considerable redesign and innovation. BNI indicates that the 5th and 6th pour caves for the removed third melter could be modified to add air handling equipment, but that would be a major modification.

5. There is essentially no more room to put in additional cooling panels in the pour caves.

6. There has been discussion on adding local cooling to the canisters to reduce the skin temperatures for handling. It should be noted, however, that the heat release rate is not changed significantly when the skin temperature is reduced because of the insulating properties of the glass itself. Such localized cooling would have to be sustained throughout the finishing line or the canisters would have to spend extended time in the buffer area. If the pour rate could be increased to the maximum capacity of the finishing line, i.e., 8.8 canisters per day or 2.2 canisters per pour cave per day, and local cooling was provided to transfer the canisters to the buffer area, the canisters would have to spend 26 hours in the buffer area to meet the current assumption on temperature limits entering the finishing line. It is estimated that 10 canisters would be resident in the buffer at one time when operating at the peak rate. There is room for 18 canisters in the buffer area. There is uncertainty whether the buffer area ventilation system could accommodate the heat load for this many canisters.

7. It is understood that there is a temperature limit for entering the finishing line related to seal welding the canister lid. A non-welded mechanical sealing system is currently under consideration and, if adopted, may change the temperature limits and the residence times in the lidding station. Those changes could affect the estimate of the peak production rate supportable by the finishing line.

8. In the CFD calculations performed by Bechtel, San Francisco, canister skin temperatures were calculated for a fast condition in which the interval from the start of pour to export to DOE is 43 hours (at a rate equivalent to about 38 MTG/day). For this interval the peak surface temperature at the time of export is 530 °F (Note this exceeds the finishing line entering temperature but was run for information). The "typical" sequence extends for 63 hours (at a rate equivalent to 28.8 MTG/day) and results in a peak surface temperature of 440 °F. The Contract states that "The temperature of the accessible external surfaces of the package shall not exceed 465 °F (alternating pour) or 550 °F (single pour) when returned to DOE." The CFD analyses were performed for single pour conditions so the Contract limits are met for either the 43 hour or 63 hour time period. In the alternating pour mode, however, it is not likely that a period significantly shorter than 63 hours could be used without exceeding the limit. Meeting the canister temperature limit for export is not limiting the production capacity considering the other limits on canister heat release rate that must be met to enter the finishing line.

9. The HVAC analysis assumes that the balance of facility heat loads and ventilation requirements are not a strong function of the throughput. BNI has confirmed that this assumption is reasonable.

4.3 Objective 3

Scope actions that could be taken to increase the capacities of systems that limit the overall LAW peak production rate below DOE-ORP extended goals.

As stated in the Background, the Contract baseline requirement for the LAW facility is equivalent to a peak production capability of 30 MTG/day with a target of 36 MTG/day. Over the longer term, ORP has established a target peak capacity for the LAW facility of 40 MTG/day. Figure 1 shows that both targets are not met for certain systems based on the current understanding of the limiting conditions of operation for these systems. Table 1 identifies potential actions that could be taken to mitigate the factors that lead to the more significant limits in the facility support systems that affect their capabilities to support increased melter production rates

5.0 SUMMARY OF OPEN ISSUES

As stated above, no open issues were identified in this review. The review concludes that the current design of the LAW melter support systems and other system involved in the production of LAW glass is sufficient to meet baseline Contract requirements.

6.0 RECOMMENDATIONS

DOE-ORP should review the actions identified in Table 1 and evaluate which should be pursued to increase the potential that the target goal for peak production rate of the LAW facility will be met over the long term.

7.0 REFERENCES

1. D-03-DESIGN-002, Design Product Oversight Plan, WTP LAW Facility, Melter Support System Capacities, May 2003

2. Contract DE-AC27-01RV14136

3. 24590-LAW-RPT-ENG-01-001, LAW Vitrification Capacity and Availability Study, September 12, 2001

4. 24590-LAW-RPT-PO-03-001, Low Activity Waste Facility Operations Research Availability Assessment, Revision 0, 4/7/2003

5. DOE-ORP presentation to Washington State Department of Ecology, June 12, 2003

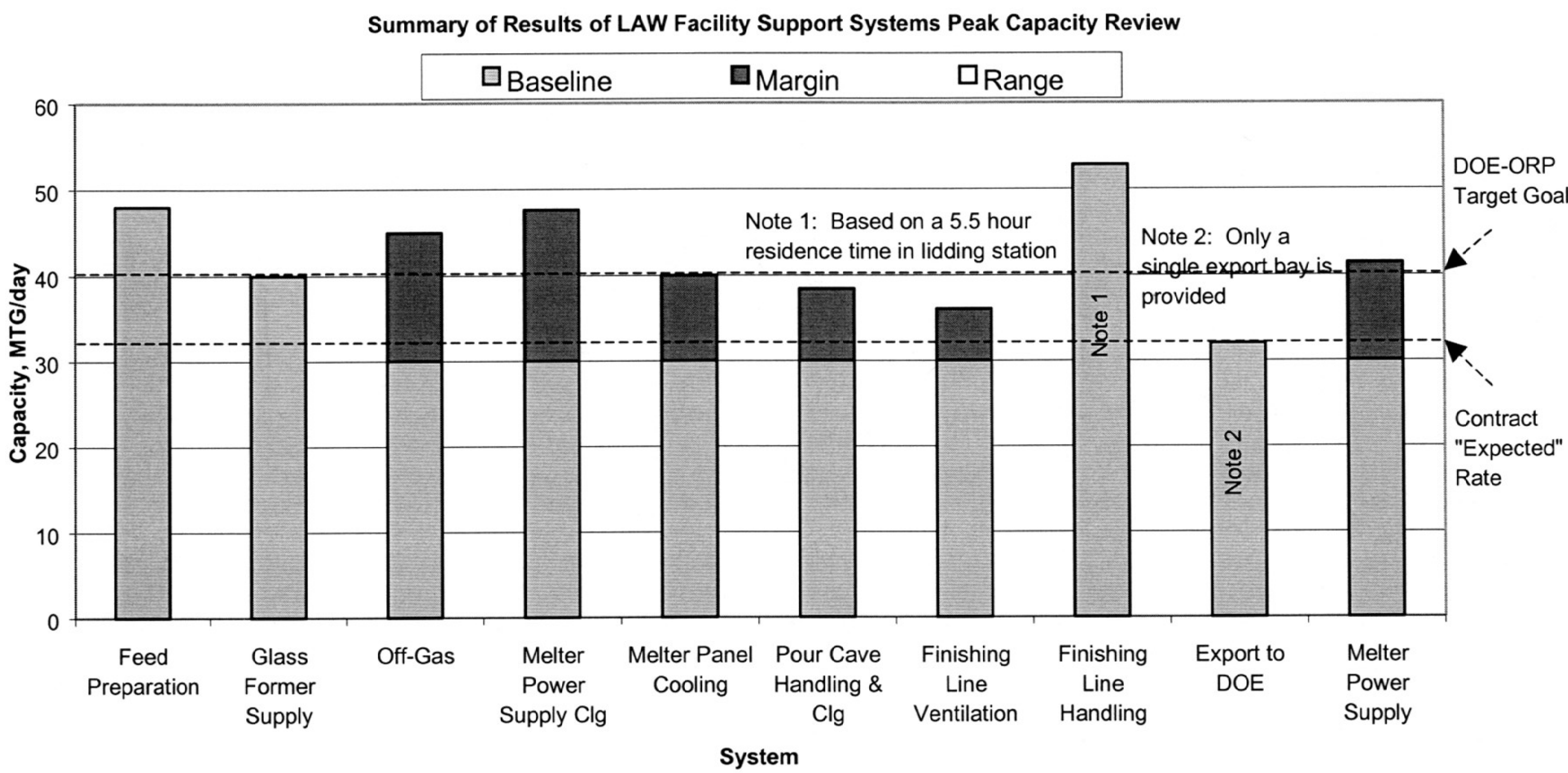
Additional references to reviewed documents are contained in the discussion of the bases for the conclusions on LAW facility capacity in Appendix A and the lines of inquiry in Appendix B.

Table 1 – Potential Actions to Improve the Limiting Conditions of Operation for Certain LAW Facility Systems

System	Bases for Limit	Potential Action to Increase Limit
Glass Former Feed	The capacity of this system was established from BNI published information.	The cited capacity of 33.5 MTG/day is not consistent with the timeline defined in the feed preparation system description which includes a 4 hour period to supply and mix in the glass formers. BNI also indicates that this is a very conservative estimate of the time required for glass former feed and mixing. BNI states that the glass former feed should not be a limiting factor in glass production. An understanding of this apparent inconsistency is needed to ensure that the limit of this system has been identified. If, after a more thorough review is made, this is established as the most limiting area, then actions that could be taken to eliminate this limit should be identified.
Off-gas System	As noted in the discussion, the design of this system is not mature enough to make a firm judgment on its peak capacity. The preliminary assessment cited herein concludes, however, that the fundamental design criteria and margins that are being considered in the design of this system should obtain a system that could support a facility production rate of 45 MTG/day.	ORP should continue to monitor the design development of the off-gas system to confirm that the judgments applied in assessing the capabilities of the system for increased melter production are realized.
Melter cooling systems	These systems supply the cooling for the melter power supplies and the cooling panel on the melter itself. This evaluation concludes that the inherent margins in the design process are sufficient to support a melter production rate of 40 to 48 MTG/day.	It is likely that reducing some of the conservatisms in the assumptions made herein on the capacity of the melter power supplies and there cooling systems would conclude that these components will support the target goal of greater than 40 MTG/day. ORP should continue to monitor the design development and implementation of these systems to confirm that these systems design margins are maintained and when complete will support the target goal.
Pour Cave and Finishing Line Cooling and Ventilation	The capacities of these systems appear to limit facility peak production to about 38 MTG/day based on current calculations of canister and area temperatures.	As noted in the discussions of these limits there are potential conservatisms in the analyses that could result in more margin in the capabilities of these systems that could

		support a 40 MTG/day production rate. The most significant of these are the assumptions on glass thermodynamic properties. The properties used in the latest analyses are bounding properties derived from the general literature and properties of glass produced at WVDP and DWPF. Tests will be completed in the summer of 2003 to establish the WTP glass properties. BNI intends to redo these analyses using the actual glass parameters to establish the design capacities of these systems. The results of these analyses can then be used to establish the capabilities of *these systems to support the target facility glass production* rate.
Finishing line and export facility	Based on the current baseline timeline the finishing line can support a production rate of about 53 MTG/day. The export facility, which is comprised of a single crane and truck bay is currently estimated to be only capable of transferring 5-1/3 canisters or 32 MTG per day. This is the most limiting area identified that affects the peak glass production rate of the facility.	It is understood that there are two principal factors that affect the rate at which canisters can be transferred out of the LAW facility to DOE for burial. These are the closure of paperwork to permit removing the canister from the LAW facility and the number of canisters that are transported on each trailer. Ensuring that these areas do not constrain the production rate of the facility does not require significant effort. The process for completing the paperwork should be streamlined and the number of canisters per trailer should be optimized.
Balance of Facility	The review reported herein concludes that the services provided by the Balance of Facility are not limiting based on current interface agreements.	ORP should continue to monitor the evolution of the critical interface agreements between BOF and LAW, e.g., Process Water, Chilled Water and Electrical, to confirm that the supply of these services does not constrain support of increased melter production rates.
Availability	The current availability estimate for the LAW facility is between 74% and 77% depending on the assumed period for bubbler replacement (8 weeks or 16 weeks). It is believed that the most limiting component in this estimate is the LAW melter system. The balance of the LAW facility support systems have availability estimates in excess of 95%.	ORP has established availability goals of 80% to 85%. To meet these goals significant increases in the melter system availabilities and maintenance of the substantial availabilities for the support systems will be required. ORP should continue to monitor the development of LAW support system availabilities to ensure that target goals are achieved.

Figure 1


Summary of Results of LAW Facility Support Systems Peak Capacity Review
Baseline
Margin
Range
Capacity, MTG/day
60
50
40
30
20
10
0
Note 1: Based on a 5.5 hour residence time in lidding station
Note 2: Only a single export bay is provided
Note 1
Note 2
DOE-ORP Target Goal
Contract "Expected" Rate
Feed Preparation
Glass Former Supply
Off-Gas
Melter Power Supply Clg
Melter Panel Cooling
Pour Cave Handling & Clg
Finishing Line Ventilation
Finishing Line Handling
Export to DOE
Melter Power Supply
System

Appendix A -- Bases for Estimates of Limiting Conditions of Operation for LAW Facility Systems

The following documents the bases for the estimates of the capabilities of the LAW melter support systems and other systems involved in the production of LAW glass on the peak production rate of the LAW facility. These estimates are independent of the production capability of the melter itself. The areas considered in this evaluation included Feed Preparation, Glass Former Feed System, Off-Gas System, Melter Cooling Panel and Power Supply Cooling Systems, Pour Cave and Finishing Line Cooling and Ventilation, Electrical Supply and the Finishing Line and Export Bay Material Handling.

A.1 Feed Preparation

A.1.1 Discussion

Figure A.1-1 summarizes the flow path and sampling plan for the LAW melter feed to confirm compliance of the glass waste form for burial [1, 2, 3 and 4]. This figure and the following discussion were developed from review of the references and discussions with cognizant BNI personnel.

The maximum ILAW glass production rate from the LAW Vitrification Plant feed system is influenced by several parameters. These are the concentration of the Na in the LAW treated feed, the Na waste loading in the ILAW product glass, the time required to sample and analyze the feed in the Concentrate Receipt Vessel (CRV), the time to prepare and transfer the feed and the capacity of the feed pumps.

The following summarizes the CRV fill, sample and transfer times based on the current feed preparation timeline [1,2]:

Filling the CRV from PT	1.7 hours
Sampling and Analysis	11.0 hours
Transfer to the MFPV	0.7 hours
Total	13.4 hours

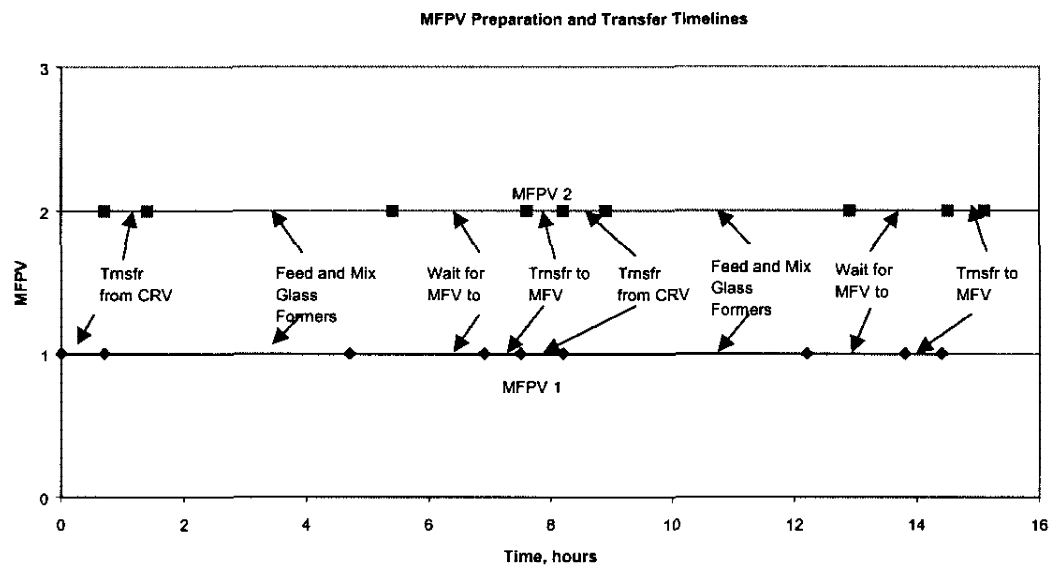
The CRV has the capacity (9,100 gallons working volume) to fill the Melter Feed Preparation Vessel (MFPV) four time before it is refilled.

The current BNI timeline indicates that it takes 4 hours to mix the waste with the glass formers in the MFPV and an additional 0.6 hours to transfer the feed to the Melter Feed Vessel (MFV) [2,3]. The total time required to transfer a batch from the CRV to the MFPV, feed and mix the glass formers and then transfer the slurry to the MFV is 5.3 hours.

The MFPV and MFV working volumes are 3,300 gallons including the volume of the waste transferred from the CRV and the glass formers and other feed constituents, e.g., sucrose. [2]. The maximum feed transfer rate to the melter is cited as 480 gph [5]. Accordingly, the MFV has 6.9 hours of capacity to feed the melter at this rate.

The current BNI baseline assumes that a single CRV will supply the two MFPV, MFV, melter lines at a time in an alternating feed mode. The transfer pumps are not sized to feed both MFPV's at the same time. Each CRV contains four MFPV waste feed batches (approximately 2300 gallons per batch). The minimum time that a CRV would have to begin resupplying both MFPVs, therefore, would be 10.6 hours; supply and preparation of four batches in an alternating mode with 5.3 hours for each preparation of the first MFPV supplied (see Figure).

This timeline is not achievable, however, when the maximum feed rate of the melter is considered. As cited above, at the maximum feed rate of 480 hours it takes 6.9 hours to empty the MFV for the next batch. Once a new MFPV batch preparation is completed it can begin to feed the MFV but can only feed at a rate that maintains the level in the MFV below maximum. If it is assumed that at the end of the transfer from the MFPV the MFV is full and it takes 4.7 hours before the MFPV is ready to resupply the MFV and the MFV has been supplying the melter at peak capacity of 480 gph, the MFV slurry volume will be reduced by 480 gallon/hour x 4.7 hours = 2256 gallons when the MFPV is ready to begin resupplying it. It will take another 2.2 hours for the MFV to be ready to be resupplied. Each MFPV preparation and transfer timeline, therefore gets extended by 2.2 hours to a net of 7.5 hours (6.9 hours to deplete the working volume of the MFV and 0.6 hours to replenish that volume from the MFPV. This increases the overall MFPV timeline by 3.7 hours from 10.6 hours to 14.3 hours. (see Figure)



This timeline assumes that while one CRV is feeding the two lines the other CRV is being filled from pretreatment and the feed sampled and analyzed to confirm it is in compliance with waste form requirements. As cited, above the CRV preparation time is currently estimated at 12.7 hours, including 11 hours for the current compliance strategy. As seen from the figure the inventory of a CRV is depleted about nine hours after the initial transfer of feed to the first MFPV. The next time an MFPV needs to be filled is about 6 hours later. At that time the other CRV will begin another feed cycle. The empty CRV therefore has about 21 hours to be filled and sampled before it will be required to feed an MFPV. This is long compared with the 12.7 hours currently estimated for those actions.

On this basis the most limiting area of the feed preparation system is the feed rate to the melter. As noted this is cited by Duratek as 480 gph. According to Duratek a glass production rate of 15 MTG/day is equivalent to a feed rate of 300 gph. On this basis a 480 gph feed rate would support a glass production rate of 24 MTG/day/per melter or 48 MTG/day for the facility.

This is likely a conservative estimate of the glass that would be produced at this feed rate based on pilot melter performance. In general, the feed rate of slurry to produce 15 MTG/day has been in the range of 180 gph. This would support a glass production rate of 40 MTG/day per melter at a 480 gph feed rate. This is an unrealistic extrapolation of performance and is not considered as a reasonable limit to be considered in this evaluation.

A.1.2 Conclusion

The analyses indicate that Contract requirements are met with the current feed preparation system capacity and timeline. The feed preparation system will support glass production rates up to 48 MTG/day (limited by the feed pump capacity). Therefore, the target production rate of 40 MTG/day is also met.

A.1.3 References

1. 24590-LAW-3YD-LCP-00001, Rev 0, "System Description for LAW Concentrate Receipt Process (LCP)", October 30, 2002, Bechtel National Inc.

2. 24590-LAW-3YD-LFP-00001, Rev 0, "System Description for Low Activity Waste Melter Feed Process System", February 12, 2003, Bechtel National Inc.

3. 24590-BOF 3YD-GFR-00001, Rev B0, "System Description for Glass Former Reagent System", March 26, 2003, Bechtel National Inc.

4. 24590-WTP-PL-RT-03-001, Rev 1, "ILAW Product Compliance Plan", April 15, 2003, Bechtel National Inc.

5. 24590-101-TSA-W000-0010-409-359, "LAW Melter System Description", Durateck document REP-WTP-11000, revision 0, November 2002

Table A.1-1

TAT: Turnaround time for Sample analysis ATA: Available time for analysis

Component	Requirement	Design Capacity	References	Comments/Discussion
System 20, LAW concentrate Receipt Process System, LCP (Simplified PFD 24590-LAW-M5K-V17T-00001)				
Sampling from CRV Vessels LCP-VSL-00001, LCP-VSL-00002 Sample no. LAW 1 1 sample/64 hour/melter	CRV samples to predict LAW glass composition to be within contract limit ATA: 32 hrs. (Based on 2 CRV operating) ATA goes down to 13.4 hrs for 1CRV operational	TAT: 10 hrs* < 13.4 hrs. (ATA) Ok.	1. 24590-WTP-PL-PR-01-004, Rev. 2, WTP Sampling and Analysis Plan 2. 24590-LAW-3YD-LCP-00001, Rev. 0, LAW Concentrate Receipt Process 3. 24590-LAW-3YD-LFP-00001, Rev. 0, LAW Melter Feed Process	LAW 1 Noted as not a hold point. However, per earlier version of Product Compliance Plan had it as "Hold Point." In non-frequent case of solids in the sample, or re-run, the TAT goes up significantly, and may be higher than ATA. **However, If LAW 1 is not a "Hold point" this may not limit production.** Even though there are some concerns, I believe, LAW 1 will not be a "Hold point. <u>**Conclusion:**</u> **Sampling process does restrict LAW capability.**
			1.	
System 20, LAW Melter Process System, LMP (Simplified PFD 24590-LAW-M5K-V17T-00001)				
Sampling of glass from canister	ATA: 7 days	TAT: 7 hrs.	1. 24590-WTP-PL-PR-01-004, Rev. 2, WTP Sampling and Analysis Plan	Not critical

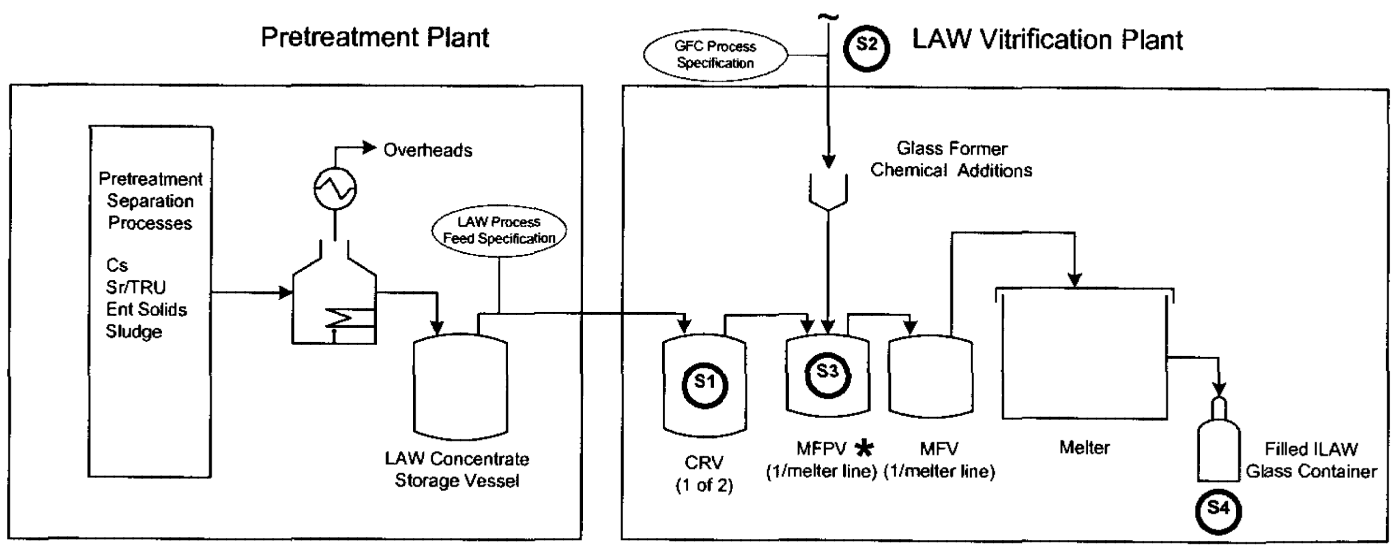
Component	Requirement	Design Capacity	References	Comments/Discussion
LAW 2			2. 24590-LAW-3YD-LCP-00001, Rev. 0, LAW Concentrate Receipt Process	
System 20, LAW Liquid Effluent System, RLD and NLD (Simplified PFD 24590-LAW-M5K-V17T-00001)				
C3/C5 Plant wash, from Vessel RLD-VSL-003/4/5 LAW 3/ 8/ 10 LAW 9 C1/C2	To determine treatment need		1. 24590-WTP-PL-PR-01-004, Rev. 2, WTP Sampling and Analysis Plan. 2. 24590-LAW-3YD-LCP-00001, Rev. 0, LAW Concentrate Receipt Process	Non-critical.
System 20, LAW Primary Offgas Process System, LOP (Simplified PFD 24590-LAW-M5K-V17T-00001)				
From cooling loop of SBS Condensate vessel LOP-VSL-0001/2/3 LAW 7	To ensure non-contamination of cooling water		1. 24590-LAW-MPC-945-00001, rev A 2. 24590-LAW-MPD-PCW-00001	Non-critical
System 20, LAW Secondary Offgas / Vessel vent Process System, LOP (Simplified PFD 24590-LAW-M5K-V17T-00001)				
From Stack LAW 12a - f	LV-S2 and S3 are sampled 2/month			Some requirement would come from NOC permit, which is not final yet.
System 20, LAW Melter Process System, LMP (Simplified PFD 24590-LAW-M5K-V17T-00001)				
From chilled water loop of Melter Pour cave LAW 13	To ensure non-contamination of cooling water			Non-critical
Process Cooling water loop of Melter LAW 14	To ensure non-contamination of cooling water			Non-critical
Process Cooling				Non-critical

Component	Requirement	Design Capacity	References	Comments/Discussion
water loop for Melter Power supply cooling LAW 15				
LAW Plant Availability				
With major failures included in the OR model	60% availability for LAW itself, so long as the LAW production is not affected by PT and other supporting facilities	74% Provides 1347 canisters vs. 11 canisters required.	1. 24590-LAW-RPT-PO-03-001 Rev. 0, LAW facility OR availability Assessment	Bubbler failure per 8 weeks (cons) However, the OR model is of 1st order, and doesn't include Off gas, plant recycles, and detailed equipment. Hence the availability would only go down and loose margins as analysis matures.

Figure A.1-1

ILAW Compositional Control Compliance Strategy

(Proposed Compliance Strategy)



Process Control and Production Reporting Samples

CRV **S1** combined with GFC Process Specification/Sample Information **S2** is used for Chemical Reporting (Specification 2.2.2.6, *Chemical Composition Documentation*) and Radionuclide Reporting (Specification 2.2.2.7, *Radionuclide Composition Documentation*

- Glass Sample **S4** taken infrequently and used for Process/Product Control Model Validation (Specification 2.2.2.2, *Waste Loading*, Specification 2.2.2.17, *Waste Form Testing* and Specification 2.2.2.20, *Dangerous Waste Limitations*)

LAW Process Specification used to ensure LAW Feed from Pretreatment will produce complaint ILAW glass.

GFC Process Specification used to ensure composition of Glass Forming Chemicals are known and controlled.

*MFPV waste feed vessel is a process Hold Point for production of ILAW glass. Chemical and Radiochemical analysis results from sample **S1** and **S2** , combined with process specification information, must demonstrate that a compliant ILAW glass will be produced, before the prepared feed (e.g. MFPV) is allowed to transfer to the MFV.

- MFPV sampled, **S3,** only if sample failure occurs in CRV, process parameters indicate incomplete transfer of GFC or treated LAW

A.2 Balance of Facility Services including Glass Former Feed System

A.2.1 Discussion

The attached tables summarize the services provided from the Balance of Facility to the LAW facility [2]. These show margin to the required values to support the baseline and increased facility capacity as discussed for each area evaluated herein.

With respect to the glass former supply system, this table indicates a design capacity of 33.5 MTG/day. Discussions with BNI personnel [1] that the time allotted to former feed and mixing (i.e., 4 hours in the current timeline) is very conservative and that the former feed system should not be considered a limiting factor in glass production. Accordingly, it has been assumed that the glass former system can support the target peak glass production rate of 40 MTG/day.

A.2.2 References

1. Report of Meeting with BNI, June 13, 2003, Summary Review of Preliminary Conclusions on ORP Oversight Evaluation of LAW Melter Support System Capacities

2. BNI System/Facility Capacities Overview, DRAFT

BOF ~ Utility Design To Date

SYSTEM	ACRONYM	BOF SUPPLY TO LAW					NOTES	DESIGN NOTES
Process Service Water System	(PSW)	Supply		Design	Flow Breakdown			1) Reference Document: • 24590-BOF-M5-PSW-00001 • 24590-BOF-M6C-PSW-00001 2) ~ A spare Chiller is included in the system design. 3) Contingency is 35 GPM*
		Pressure	Temp	Flow Rate	Cont. Flow	Ops Flow		
1) BOF PSW		72.5 PSIG	60 Deg F	400 GPM		230 GPM +		
a) Chiller Make-up ~		72.5 PSIG	60 Deg F	20 GPM		20 GPM		
b) Glass Former		72.5 PSIG	60 Deg F	60 GPM		60 GPM		
c) Melter Assy Pad		72.5 PSIG	60 Deg F	40 GPM		40 GPM		
d) Wet Chem Storge		72.5 PSIG	60 Deg F	75 GPM		75 GPM		
e) Demin Tank		TBD	60 Deg F			158 GPM		
2) LAW PSW		72.5 PSIG	60 Deg F	150 GPM*		50 GPM*		
3) HLW PSW		72.5 PSIG	60 Deg F	197 GPM*		110 GPM*		
4) PT PSW		72.5 PSIG	60 Deg F	75 GPM*		10 GPM*		
5) LAB PSW		-	-	-		-		
6) LAW Alternate Tech PSW		72.5 PSIG	60 Deg F	150 GPM		50 GPM*		
Demineralized Water System	(DIW)	Supply		Design	Flow Breakdown			1) Reference Document: • 24590-BOF-M5-DIW-00001 • 24590-BOF-M6C-DIW-00001 2)
		Pressure	Temp	Flow Rate	Cont.Flow	Max Need		
1) BOF DIW				265 GPM*	86.8 GPM	199825 GPD		
a) Wet Chemical			Ambient	75 GPM	16.0 GPM	29000 GPD		
b) Steam Plant			Ambient	190 GPM	47.0 GPM	128025 GPD		
2) LAW DIW			Ambient	80 GPM	6.6 GPM	1200 GPD		
3) HLW DIW			Ambient	75 GPM	3.0 GPM	4000 GPD		
4) PT DIW			Ambient	160 GPM	8.2 GPM	11800 GPD		
5) LAB DIW			Ambient	120 GPM	1.0 GPM	3000 GPD		
6) LAW Alternate Tech DIW			Ambient	80 GPM	6.6 GPM	12000 GPD		
Plant Cooling Water System	(PCW)	Supply/Return		Design Ops	Misc.			1) Reference Document: • 24590-BOF-M5-PCW-00001 • 24590-BOF-M0C-PCW-00001 2) ~ The Chiller Compressor Design Rate is intermittent (139 GPM*). 3)
		Pressure	Temp	Rate	BTU/HR	Current GPM		
1) BOF PCW								
a) Steam Plant					19800000*		(Boiler Blowdown)	
b) Chiller/Compressor		TBD	77/92.7 Deg F	139 GPM~		139 GPM~		
c) Cooling Tower Supply		TBD	77 Deg F	15515 GPM		14890 GPM	(To Distribution)	
d) Cooling Tower Blowdown				29455 GPM		26100 GPM		
e) Wet Pit Pump				170 GPM		136 GPM		

(*) Asterisk items are from a BNI draft document named "BOF System/Facility Capacities Overview" showing approximate figures.
Areas that are highlighted in yellow are TBD.

System	Code	Pressure	Temp	Rate	Cont. Flow	Flow Peak	Notes
Discharge				29455 GPM		26100 GPM	
2) LAW PCW		TBD	77/90.5 Deg F	1980 GPM	13980000*	1980 GPM	
3) HLW PCW		TBD	77/88.2 Deg F	1580 GPM	4662500*	830 GPM	
4) PT PCW		150 FT of H20	77/89 Deg F	8400 GPM	5040000*	8400 GPM	
5) XXXXXXX		-	-		-	-	
6) LAW Alternate Tech PCW		172 FT of H20	77/91.2 Deg F	1980 GPM	-	0	

Domestic Water System	(DOW)	Supply		Design	Flow Breakdown		Notes
		Pressure	Temp	Rate	Cont.Flow	Flow Peak	1) Reference Document: • 24590-BOF-M5-DOW-00001 • 24590-BOF-M0C-DOW-00001
1. BOF DOW		60-75 PSIG		262 GPM*			
a. Steam Plant		60-75 PSIG		42 GPM			
b. Chiller/Compressor		60-75 PSIG		45 GPM			
c. Melter Assembly		60-75 PSIG		107 GPM			
d. Wet Chem		60-75 PSIG		30 GPM			
e. Water Treatment		60-75 PSIG		37 GPM			
f. Fuel Oil PH		60-75 PSIG		6 GPM			
g. Glass Former		60-75 PSIG		73 GPM			
h. ITS SG		60-75 PSIG		30 GPM			
i. Admin Building		60-75 PSIG		92 GPM			
2. LAW DOW		60-75 PSIG		146 GPM			
3. HLW DOW		60-75 PSIG		143 GPM			
4. PT DOW		60-75 PSIG		147 GPM			
5. LAB DOW		60-75 PSIG		112 GPM			
6. LAW Alternate Tech DOW		60-75 PSIG		76 GPM			

RAW Water System	(RAW)	Supply to BOF		Notes
		Design	Capacity	1) Reference Document: See Footnote below*
1) BOF RAW Water		580 GPM*	875 GPM*	

Chilled Water System	(CHW)	Supply/Return		Design	Misc.	Notes
		Pressure	Temp	Rate GPM	BTU/HR	1) Reference Document: 24590-BOF-M5-CHW-00001 2) Closed Loop System. 3) Supplied up to Facility Battery limits. 4) CHW for HVAC and Process Loads. 5) Building cooling provided by HVAC fan coil units and air handling units equipped with chilled water coils. 6) Inside LAW CHW is supplied to the heat exchangers,
1) BOF CHW		65/85 PSIG	41/56 Deg F	Recirc*	19800000*	
2) LAW CHW		125/90 PSIG	41/56 Deg F	3024	22,037.00*	
3) HLW CHW		125/90 PSIG	41/56 Deg F	1975*	14810760*	
4) PT CHW		125/90 PSIG	41/56 Deg F	3200	24100000*	
5) LAB CHW		125/90 PSIG	41/56 Deg F	900	6750000*	
		TBD	41/56 Deg F	TBD	TBD	

(*) Asterisk items are from a BNI draft document named "BOF System/Facility Capacities Overview" showing approximate figures.
Areas that are highlighted in yellow are TBD.

								Notes
6) LAW Alternate Tech CHW								miscellaneous equipment. 7) CW to HLW, LAB, LAW, MAB PT Annex HVAC Units.

Steam System:	HPS LPS Supply	Supply		Design	Flow Breakdown		Notes
		Pressure	Temp	Lbs/Hour	Cont.Flow	Peak Flow	1) **Reference Document: 24590-BOF-M5-HPS-00001** 2) HPS is used within buildings for steam ejectors, melter film coolers, conversion into heating ventilation, air conditioning (HVAC) loads and LP steam. 3) LP steam is used for process heating and space heating within buildings. Supplied at 40 psig and 286 deg f.
1. BOF Steam System HPS				30220 *			
BOF Steam System LPS							
a) Glass Former HPS		109 PSIG	343 deg F	100	0		
Glass Former LPS		40 PSIG	286 deg F				
b) Water Treatment HPS		109 PSIG	343 deg F	100	0		
Water Treatment LPS		40 PSIG	286 deg F				
c) Steam Plant HVAC HPS		TBD	TBD	12000	0		
Steam Plant HVAC LPS		TBD	TBD				
d) Melter Assembly HPS		TBD	TBD	TBD	TBD		
Melter Assembly LPS							
2. LAW Steam System HPS		109 PSIG	343 deg F	21000	1300lbs/hr		
LAW Steam System LPS		40 PSIG	286 deg F				
3. HLW Steam HPS		109 PSIG	343 deg F	30800*	29800lbs/hr		
HLW Steam LPS		40 PSIG	286 deg F				
4. PT Steam HPS		109 PSIG	343 deg F	107200	86700lbs/hr		
PT Steam LPS		40 PSIG	286 deg F				
5. LAB Steam HPS		109 PSIG	343 deg F	17400	17400lbs/hr		
LAB Steam LPS		40 PSIG	286 deg F				
6. LAW Alternate Tech HPS		TBD	TBD	TBD	TBD		
LAW Alternate Tech LPS		TBD	TBD	TBD	TBD		

Plant Service Air System	(PSA)	Supply		Design	Flow Breakdown		Main Distribution		Design	Notes
		Pressure	Temp	Rate SCFM	Flow Type	Rate SCFM	Pressure	Temp	Rate SCFM	1) **Reference Document:** • 24590-BOF-M5-PSA-00001 • 24590-BOF-M6C-PSA-00001 • CCN: 039136 2) Users: PT, HLW, LAW, LAB and LAW Alternate Tech Blding 3) Underground distribution piping will handle ISA and PSA for Process Buildings 4) Distribution piping to BOF will be aboveground and will handle ISA and PSA for BOF 5) Not included: • PSA Glass Former • PSA of ITS Application to prevent **Hydrogen Accumulation** • Breathing Air for Process Buildings 6) Demand: PSA Usage, ISA Usage, BOF PSA is source for ISA
1. BOF Plant Service Air		135 PSIG	100 deg F	115			135psi	100 deg F	8800	
2. LAW Plant Service Air		130 PSIG	60 deg F	8600*	Intermittent					
3. HLW Plant Service Air		130 PSIG	60 deg F	15500						
4. PT Plant Service Air		130 PSIG	60 deg F	50400						
5. LAB Plant Service Air		130 PSIG	60 deg F	120						
6. LAW Alternate Tech Service Air		130 PSIG	60 deg F	4400	Intermittent					

(*) Asterisk items are from a BNI draft document named "BOF System/Facility Capacities Overview" showing approximate figures.
Areas that are highlighted in yellow are TBD.

NR/NDL Effluent System	(NLD)	Discharge To Tank Pressure	Discharge To Tank Temp	Transfer Rate	Batch Volume	Transfer Frequency	Total Dissolved Solids PPM	Flow Type	
1) BOF NR/NDL Effluent									1) Referenced Document: 24590-BOF-M5-NLD-00001
a) Steam Plant		30-50 PSI	68-115 Deg F	3 - 83 GPM	-	-	250 PPM	Continuous	
b) Chiller Compressor		20 PSI	50-80 Deg F	20 GPM	-	3/Week	90-120PPM	Intermittent	
c) Water Treatment		25-30 PSI	60-80 Deg F	84-450 GPM	-	-	250 PPM	Intermittent	
d) Cooling Tower		25-30 PSI	45-80 Deg F	50-350 GPM	-	-	250 PPM	Continuous	
e) NLD PH/Sump		15-20 PSI	35-113 Deg F	20 GPM	-	1/Month	90 PPM	Intermittent	
f) Glass Former		30-50 PSI	60-80 Deg F	20 GPM	-	-	90 PPM	Intermittent	
g) NLD PH/Discharge		15-20 PSI	80-100 Deg F	450 GPM	200000	1/Day	250 PPM	Intermittent	
h) Wet Chemical		40-60 PSI	60-80 Deg F	50 GPM	2000	1/Week	250 PPM	Intermittent	
2) LAW NR/NDL Effluent		30-50 PSI	60-80 Deg F	100 GPM	10000 Gal	3/WK	90 PPM	Intermittent	
3) HLW NR/NDL Effluent		30-50 PSI	60-80 Deg F	80 GPM	1500 Gal	3/WK	90 PPM	Intermittent	
4) PT NR/NDL Effluent		40-80PSI	60-80 Deg F	50 GPM	1750 Gal	3/WK	90 PPM	Intermittent	
5) LAB NR/NDL Effluent		30-50 PSI	60-80 Deg F	30 GPM		3/WK	90 PPM	Intermittent	
6) LAW Alternate Tech NR/NDL		30-50 PSI	60-80 Deg F	100 GPM	10000 Gal	3/WK	90 PPM	Intermittent	

Fuel Oil System	(DFO)	Fuel Oil (ITS & SDG) Day Tanks/Supply Pressure	Design Flow Rate	Fuel Oil (ITS & SDG) Polishing Filter Pressure	Design Flow Rate	Fuel Oil Storage Tank to BOF Systems – Steam Plant Pressure	Steam Plant Design Flow	Fuel Unloading Pressure	Fuel Unloading Design Flow	
1) BOF Fuel Oil		51 FT Head	100 GPM	30 FT Head	20 GPM	38 Ft Head	250 GPM	210 Ft Head	40 GPM	1) Reference Document: 24590-BOF-M5-DFO-00001

Steam Condensate Water	(SCW)	Condensate Return Pressure	Condensate Return Temp	Design Rate	Flow Breakdown Cont Flow	Flow Breakdown Peak Flow	
1) BOF Steam Condensate				263 GPM*			1) Reference Document: 24590-BOF-M5-SCW-00001
a) Glass Former				0.2 GPM	0.2 GPM		
b) Water Treatment				0.2 GPM	0.2 GPM		
c) Steam Plant HVAC				0.4 GPM	0.4 GPM		
d) Melter Assembly				TBD	TBD		
e) Deaerator				TBD	TBD		
2) LAW Steam Condensate				35 GPM*			
3) HLW Steam Condensate				46 GPM*			
4) PT Steam Condensate				132 GPM*			
				34 GPM*			

(*) Asterisk items are from a BNI draft document named "BOF System/Facility Capacities Overview" showing approximate figures.
Areas that are highlighted in yellow are TBD.

5) LAB Steam Condensate 6) LAW Alternate Tech SC				TBD	TBD								
Electrical Power Supply	(MW)	Supply									2) Reference Document: See Footnote below*		
		MW											
1) BOF Electrical Power		23.043*											
2) LAW Electrical Power		7.509*											
3) HLW Electrical Power		10.275*											
4) PT Electrical Power		6.059*											
5) LAB Electrical Power		7.509*											
6) LAW Alternate Tech Power		TBD											
Glass Formers-GFF	(GFF)	Supply			GFF System		Stream Name	Rate	LAW GFF	HLW GFF	Stream Name	LAW GFF	HLW GFF
		MTG/Day	Peak MTG/Day		BOF Total	BOF Capacity					9) Sodium Carbonate	0	3.2
1) BOF GFF		0			40 MTG/D*	133.8 MTG/D*	1) Aluminum Silicate	WT% Batch	2.86	0	10) Sucrose	10.6	1.31
2) LAW GFF		33.5*	36.0			LAW	2) Borax	WT% Batch	0	27.0	11) Titanium Dioxide	3.36	0
3) HLW GFF		6.5*				HLW	3) Boric Acid	WT% Batch	19.7	0	12) Zinc Oxide	4.93	3.05
4) LAW Alternate Technology		0					4) Calcium Silicate	WT% Batch	6.81	0	13) Zirconium Silicate	0	0
					Approximately: 33.5 MTG/Day = The Facility Design Capacity A Facility Availability Factor of 71% = 23.785 MTG/Day = Waste Treatment Capacity.		5) Ferric Oxide	WT% Batch	3.36	0			
							6) Lithium Carbonate	WT% Batch	0	16.1			
							7) Magnesium Silicate	WT% Batch	2.96	0	1) Referenced Document: 24590-BOF-M5-V17T-00008 (2/03) 24590-BOF-MTC-GFR-00002 (4/03)		
							8) Silica	WT% Batch	45.4	49.3			
Sodium Nitrite Reagent System 1) PT Sodium Nitrite Reagent													
Sodium Permanganate Reagent System 1) PT Sodium Permanganate Reagent System													
Strontium Nitrite Reagent System 1) PT Strontium Nitrite Reagent System													
Nitric Acid Reagent System 1) HLW Nitric Acid Reagent System 2) PT Nitric Acid Reagent System													
Sodium Hydroxide Reagent System 1) HLW Sodium Hydroxide Reagent System 2) PT Sodium Hydroxide Reagent System													

(*) Asterisk items are from a BNI draft document named "BOF System/Facility Capacities Overview" showing approximate figures. Areas that are highlighted in yellow are TBD.

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A.3 LAW Melter Offgas Treatment

A.3.1 Background

The capacity of the LAW offgas system cannot be analyzed with accuracy at this time because the requirements for most of the system are still under development. Only the Wet Electrostatic Precipitators and the HEPA filters/housings have been specified in detail, although the HEPA specifications are boilerplate requirements that must be augmented with application-specific data. Preliminary LAW melter offgas system design requirements developed earlier are currently being reanalyzed by BNI to enable completion of final design specifications for the majority of the equipment items. These specifications will be prescriptive, but much will be left to the vendors to specify. The vendors also are required to warranty their equipment. Therefore, some time will be required before a detailed analysis of the potential excess capacity of the offgas system can be performed.

BNI also is developing process flowsheets for the offgas system as a primary basis for developing the specifications. A process flowsheet developed for a typical Envelope A feed is considered the current bounding case for design purposes (24590-LAW-M4C-20-00001, Rev A). This is because Envelope A waste would be processed at the highest waste throughput rate, resulting in the highest mass flow rates of water vapor, NOX, CO, entrained solids, I-129, and other important waste species in the offgas stream. The Envelope A waste stream may not be bounding for all waste species of interest, however. Moreover, BNI has not yet developed a detailed bounding analysis that considers factors such as normal processing variability, upset conditions, equilibrium recycle conditions, and other conditions that may elevate mass flow rates of species of interest in the offgas stream. Such an analysis is being considered by BNI.

In the absence of final specifications and a final bounding flowsheet analysis, the potential level of excess capacity of the offgas system was roughly analyzed based on (1) data in the current Envelope A process flowsheet (24590-LAW-RPT-ENG-02-004, Rev 0), (2) preliminary offgas system requirements, (3) other data and anticipated requirements provided by BNI, and (4) simplifying assumptions, as described below. Much of the analysis below is based on the SBS and the SCR since they are the components most likely to limit the throughput capacity of the offgas system.

A.3.2 Discussion of Factors Affecting Maximum Capacity

Table A.3-1 summarizes the design requirements and projected capacities (up to a factor of 2X the current capacity) for the major components of the off-gas system. These requirements and capacities provide the bases for the following discussions of (1) factors that affect the capacity and (2) likely impacts of melting at 2X the baseline glass production rate (i.e., at 30 MTG/day/melter).

The LAW melter offgas discharged to the SBS contains the following nominal gas composition (24590-LAW-RPT-ENG-02-004, Rev 0):

- Waste water vapor, 25 parts
- Acid gases, 3 parts
- Air inleakage and instrumentation, 29 parts
- Entrained aerosols, 0.2 parts
- Film cooler air, 11 parts
- Film cooler steam, 10 parts
- Control air, 22 parts

TOTAL, 100 parts

The melter system is being designed to accommodate a 3X episodic surge in the normal noncondensable offgas rates and a 7X episodic surge in the normal condensable offgas rate (24590-LAW-RPT-ENG-02-004, Rev 0). In the offgas composition above, the waste and glass forming chemicals together contribute 25 parts as condensables and 3 parts as noncondensables. The noncondensables are assumed to be primarily SOX, NOX, COX, and various other acid species of relatively small concentrations. Condensation of water is the largest source of heat that must be removed in the SBS. Based on rough calculations of the relative energy required to condense the steam in the offgas versus cool the offgas from 250 C to 50C in the SBS, about 2/3 of the cooling power load on the SBS (1,520,000 Btu/hr) is for condensation, i.e., 1,000,000 Btu/hr is for condensing steam and 520,000 is for cooling noncondensables. The fraction of the capacity reserved for condensing the waste steam is about 710,000 Btu/hr since 10 parts of the water vapor requiring condensation are provided by the film cooler ((1,000,000)(25)/(25 + 10) = 710,000). If the capacity of the melters were to be increased by 100% (to 30 MTG/d for each melter), the waste steam fraction would increase to 50 parts, assuming no change in the concentration of the melter feed. This steam also must be condensed in the SBS. The cooling load for condensing waste steam then would double to 1,420,000 Btu/hr (2 X 710,000 = 1,420,000).

The preliminary design cooling capacity of the SBS is reportedly 2,997,000 or 3,000,000 Btu/hr (24590-WTP-RPT-02-012, Rev 0). Since the film cooler would be shut off at the onset of an offgas surge, the SBS must accommodate the surge in waste condensables as well as the flow of noncondensables. At a melting rate of 15 MTG/d, the reserve for accommodating the surge is 1,770,000 Btu/hr (3,000,000 – 520,000 – 710,000 = 1,770,000) and at 30 MTG/d it is reduced to 1,060,000 Btu/hr (3,000,000 – 520,000 – 2(710,000) = 1,060,000) assuming the contribution to cooling the additional acid offgases in the surge is relatively insignificant and or offset by reduced in-leakage during the surge. Thus, at 15 MTG/day, the reserve of 1,770,000 BTU/hr appears nearly adequate to accommodate an additional 2.5X (1,770,000/710,000 = 2.5) the normal waste-steam condensation rate of 1,420,000 BTU/hr, resulting in the ability of the SBS to accommodate an extended 3.5X surge (1X + 2.5X = 3.5X) at a 15 MTG/day melting rate under isothermal conditions.

However, the large size of the SBS provides considerable thermal inertia, an important factor in the case of the expected short-duration surges. To meet the needs for an extra 3.5X cooling (7X – 3.5X = 3.5X) during the surge to satisfy the requirement to accommodate the 7X surge requirement of 2,490,000 Btu/hr (3.5 X 710,000 BTU/hr = 2,490,000), the water in the SBS can be heated, but to a level that does not result in boiling. The liquid content of the SBS can be approximated to that contained in a cylinder ~5 ft high by ~10 ft in diameter (24590-LAW-LOP-SCB-00001). This is equivalent to 24,500 pounds of water (3.14)(5')(5')(5')(62.4#/ft3) = 24,500#). The length of the surge will usually not exceed one minute. Therefore the inertial cooling requirement is 41,500 Btu ((1/60)(2,490,000 Btu/hr) = 41,500 Btu). The water in the SBS can probably be heated from the nominal 50 C to ~80 C and achieve effective condensation of the excess steam in the surge. Under these conditions, the water in the SBS provides 1,320,000 Btus of cooling reserve ((24,500#)(80 C– 50 C)(1.8 F/C)(1 Btu/#-F) = 1,320,000 Btu). This reserve would accommodate a surge lasting 32 minutes ((1,320,000/41,500) = 32).

The isothermal reserve for surges provided by the cooling water coils in the SBS for the 2X melting rate condition is about 1.5X the normal waste-water condensation rate of 710,000 BTU/hr (1,060,000/710,000 = 1.5). Thus, the 2X melting rate case could accommodate an extended 2.5X surge under isothermal conditions. To meet the needs for an extra 4.5X cooling (7X – 2.5X = 4.5X) during the surge to satisfy the 3,200,000 Btu/hr requirement to accommodate the 7X surge (4.5 X 710,000 = 3,200,000), the water in the SBS can be heated, but not to a level that results in boiling. Therefore the inertial cooling requirement is 53,300 Btu for a one minute surge ((1/60)(3,200,000) = 53,300). The water in the SBS can probably be heated from 50 C to ~80 C and achieve effective condensation of the excess steam in the surge. Under these conditions, the water in the SBS provides 1,320,000 Btus of cooling reserve ((24,500)(80 – 50)(1.8)(1) = 1,320,000). This reserve would accommodate a surge lasting 25 minutes ((1,320,000/53,300) = 25). The slightly reduced margin for cooling surges is very likely acceptable, especially because the use of bubblers in the LAW melters has significantly reduced the magnitude of offgas surges.

The ability of the SBS to accommodate the added noncondensables arising from the 2X change in melting rate also was estimated. The offgas flow rate to the SBS is shown in the process flowsheet to be 2780 ACFM for one 15-MTG/d melter. The gas includes 65% noncondensables discussed above. Thus, the rate at which noncondensables are discharged to the scrubber is 1807 ACFM (2780 X 0.65 = 1810) at 252 C. The noncondensables include control air and film cooler air that can be stopped at the onset of a surge. So subtracting this fraction, the noncondensable gas discharged to the SBS during a surge will contain only about 32% of the total offgas, or 890 ACFM at 252 C (.32 X 2780 = 890). Much of the inleakage will be reduced during a surge event due to the smaller pressure differential that would exist between the melter plenum and the melter enclosure, so the noncondensable fraction will be even lower than 32% under surge conditions.

The 3X requirement for accommodating the noncondensables under surge conditions implies that the SBS must be able to accommodate 3 times the normal flow of the uncontrolled noncondensables, or 2,670 ACFM (890 x 3 = 2668) at the scrubber inlet temperature of about 252 C. (Actual offgas temperatures during a surge are likely to be in the range of 400 C, however, due to curtailing film cooler air and steam.) The offgas must be cooled in the SBS to 52 C, resulting in a nominal rate of 1446 ACFM at the exit of the scrubber (per the process flowsheet, 24590-LAW-M4C-20-00001, Rev A). At this temperature the gas holds about 14% water under saturated conditions. After subtracting the gas volume associated with the water content of the offgas and adjusting for a 400 C temperature (assuming a perfect gas), the equivalent noncondensable gas flow is 2580 ACFM ((1 - .14)(400 + 273)/(52 + 273)(1446) = 2580), which is about that required to satisfy the 3X criterion of 2670 ACFM.

If the melter throughput rate were to double, the acid gas fraction would double to 6 parts, but the in-leakage rate would remain the same, as would the controllable sources of noncondensable and condensable gases (29 parts total for the other two sources of noncondensable gases). In this case, the noncondensable uncontrolled offgas rate would increase from 890 ACFM to 973 ACFM ((6 + 29)/(3 + 29)(890) = 973). Tripling this rate yields 2920 ACFM (3 X 973 = 2920). This rate is equivalent to reducing the surge capacity for noncondensables to 91% of the current level (2668/2920 = .91). Thus, doubling the melter throughput would lower the scrubber's ability to accommodate the increased gross flow of noncondensables to 2.7X (.91 X 3X = 2.7). The SBS (and the remainder of the offgas system as shown on table A.3-1) are likely capable of accommodating the small (~10%) increase in noncondensable rates that would result from doubling the glass throughput rate within the design margins of the equipment.

Doubling the glass throughput rate however would result in doubling the concentrations of acid gases and I-129 that must be removed in downstream processes, since the removal efficiencies (decontamination factors) for these species would not be significantly affected by changes in concentrations of these gases in the offgas stream. Thus the loads for (1) removing I-129, SO_2, and HF by the sulfur-impregnated carbon bed, (2) oxidizing CO in the catalytic oxidizer, (3) reducing NOX in the SCRs, and (4) scrubbing acid gas residues in the caustic scrubber would approximately double. The loading rate of I-129 and acids on the carbon bed will increase by a factor of 2X, resulting in doubling the rate of changeout of the bed material. Because BNI plans to install parallel carbon bed systems that can be isolated from one another, it is doubtful the 2X higher changeout rate would be a process-limiting factor considering the relatively low loading rate expected. The catalytic systems must be operated continuously, and it is doubtful the vendors who develop the detailed specifications will provide the ability to handle double the nominal teatment rate (including additional reserve for off-normal conditions), especially for treating NOX due to the added cost of dealing with the heat generated in the NOX/ammonia reaction. The additional heat generated at the 2X melting rate conditions would elevate the temperature of the offgas exiting the SCR by an additional 200 – 400 C (depending on the ratio of NO/NO_2 in the thermodynamic calculations).

NOX may be formed at these higher temperatures rather than eliminated, necessitating a heat exchanger to cool the gas. A heat exchanger is currently not included in the BNI Baseline. Thus, the likelihood of conservatism in the design capacity of the SCRs might allow up to a 50% higher NOX processing rate, but a 100% rate seems unlikely.

A.3.3 Conclusion

Because the LAW offgas system is largely unspecified, its capacity to accommodate higher melting rates cannot be analyzed with confidence at this point in time. BNI intends to award design-build subcontracts to vendors who must warranty the performance of the provided equipment. Thus it is likely the equipment will be conservatively designed, affording margin for higher glass processing rates. It is doubtful the margin will be 100% for destroying NOX, although the margin for other offgas processing units appears likely to be in the 100% range. The SCR margin may allow for 50% higher glass processing rates, and design changes that could increase the capacity by 100% appear feasible. For purposes of this rough analysis, it should be assumed the offgas system will allow a 50% increase in glass-processing rates, but probably not higher unless changes are made to the SCR system. Increasing the melting rate will result in increases in rates of waste recycle from the LAW melter offgas system to PT and ETF/LERF. These impacts are outside the scope of this analysis, but may be significant.

A.3.4 References

24590-LAW-RPT-ENG-02-004, Rev 0, *LAW First Order RAM Data Development and Assessment Report*, April 4, 2003.

24590-LAW-M4C-20-00001, Rev A, *LAW Mass, Heat, and Pressure Balance*, August 21, 2002.

24590-LAW-LOP-SCB-00001, *Process Data Sheet: Submerged Bed Scrubber*, February 22, 2002.

Table A.3-1
LAW Melter Support Systems
LAW Melter Offgas Treatment

Note: The following information represents a compilation of information drawn from numerous sources. Requirements and specifications for most of the unit operations that make up the LAW Melter Offgas System have not been finalized. Much of the information below is evolving. Discrepancies in some of the data below are indicative of the evolving nature of the specifications. Flow, temperature, pressure, and humidity data shown for the various unit operations below are for the inlet gas stream to the unit operation.

Component	Average Processing Requirement	Design Capacity	References	Comments/ Discussion
Overall System	Overall Chilled Water Demand, 4400 kBtu/hr (2)	Nameplate Case Chilled Water Demand, 5994 kBtu/hr (3) Must handle 3X normal noncondensable flow and 7X normal steam flow (1) Must maintain melter pressure at nominal –4 to –6 inches W.G. (1)	(1) 24590-LAW-RPT-ENG-02-004, Rev 0 (2) 24590-WTP-RPT-PT-02-007, Rev 0 (3) 24590-WTP-RPT-PT-02-012, Rev 0	The 3X and 7X design factors now are more conservative since the use of bubblers in the LAW melter has been shown to reduce pressure surges significantly. Pressure surges that somewhat exceed the capacity of the offgas system (i.e., maintain the offgas within the confines of the melter) are vented to the melter enclosure, which exhausts to the C5 vent system. Only when the pressure within the melter enclosure exceeds the pressure in the melter gallery would gas venting to the melter gallery occur. (24590-LAW-RPT-ENG-02-004, Rev 0) If one were to double the melting rate, the rate of acid gases would double. However, since the acid gases comprise only about 5% of the noncondensables, the higher flow rate of noncondensables through the bulk of the offgas system would have a negligible effect on the ability of the offgas system to maintain the desired flows and pressures since the system is designed to

				accommodate pressure surges of 3X the normal noncondensables flow rate. Pressure surges occurring at 2X the normal melting rate would not be expected to vary significantly in amplitude or duration from those at current melting rates unless the melting areas of individual melters are substantially increased. Thus the pressure and flow ratings of the overall offgas system are unlikely to be impacted appreciably at 2X melting rates.
Film Cooler LOP-FCLR-00002	Melter offgas fractions to SBS (based on 15 MTG/d, but should generally apply to any capacity as well) (1) • Waste water vapor, 25% • Acid gases, 3% • Air inleakage and instrumentation, 29% • Entrained aerosols, 0.2% • Film Cooler Air, 11% • Film cooler steam, 10% • Control air, 22% • Overall gas to SBS, 2780 ACFM Melter Offgas (basis: 15 MTG/D) • 1552 kg/hr (2) • 2105 ACFM (2) • 975 mbar (2) • 400 C (2) Steam Inbleed • 200kg/hr (2)	Steam Inbleed, ~232 kg/hr	(1) 24590-LAW-RPT-ENG-02-004, Rev 0 (2) 24590-LAW-M4C-20-00001, Rev A (3) 24590-WTP-RPT-PT-02-007, Rev 0	Both air and steam injected into the film cooler are shut off temporarily in the event of a pressure surge. This reduces the potential for a surge in offgas pressure to exceed the venting capability of the offgas system. The steam and air injected into the film cooler are essential to preventing the buildup of solids in the pipeline from the melter to the SBS. The routine use of air and steam in the film cooler has no impact on the capacity of the offgas system since both streams can be curtailed as needed.

	• 231 ACFM (2) Air Inbleed • 329 kg.hr (2) • 170 ACFM (2)			
SBS LOP-SCB-00001	Offgas • 2760 kg/hr (1) • 2868 ACFM (1) • 971 mbar (1) • 253 C (1) Cooling • Cooling Power, 444 kW (1) • Cooling Power, 1,520,000 Btu/hr (3) • Total Cooling Flow, 154 gpm	• Cooling Power, 2,997,000 Btu/hr (2) • 1700 ACFM (3) • 16.7 psia (4) • Vessel, 212 F (4) • 15 psig design max (Figley) • Full vacuum design min (Figley) • -2.2 psig operating min, or 850 mbar (Figley)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-WTP-RPT-PT-02-012, Rev 0 (3) 24590-LAW-LOP-SCB-00001 (4) 24590-MEC-LOP-00006	The SBS removes nearly all of the steam evaporated from the melter and the steam injected into the film cooler from the offgas stream. Small amounts of the acid gases evolved from the decomposition of the waste also are removed. The specifications for the SBS are under development. The preliminary cooling power capability of the SBS (2,997,000 Btu/hr) provides a basis for assessing the ability of the SBS to accommodate higher melting rates and the associated higher offgas rates.
SBS Condensate Vessel LOP-VSL-00001	Scrub Solution • 480 kg/hr (1) • 50 C (1) Cooling • Cooling Power, 82 kW • Total Cooling Flow, 100 gpm	• 16.7 psia (2) • 212 F (2)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LOP-00006	The additional cooling capacity of the SBS Condensate Vessel augments the cooling capacity of the SBS to a small extent, providing a small cooling buffer.
WESP LOP-WESP-00001	Offgas • 2301 kg/hr (1) • 1471 ACFM (1) • 891 mbar (1) • 52 C (1) Spray Air • 17 Kg/hr (1) • 9 ACFM (1) Bulge Purge Air	• 13.05 psia (2) • 455 F (2) • 1400 ACFM nominal flowrate (Clark) • 1000-2000 ACFM flow range • +1 to –1 atm design pressure range (Clark) • -45 inches W.G. (about	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LOP-00006	The WESP is one of only two offgas components that are specified at present. The 2000 ACFM capacity includes about 144 ACFM air added in the WESP, leaving 1856 ACFM contributed from the melter and film cooler. If the melting rate were to double, the rate of acid gases from the melter would double, but because the acid gases comprise such a small fraction of the noncondensables, the nominal flow rate

	• 218 kg/hr (1) • 135 ACFM (1) Water Add • 94 kg/hr (1)	880 mbar) nominal operating pressure (Clark) • 45 to 170 F temperature range, 121 +/- 15 F nominal (Clark) • 0-100% relative humidity range, 85 % nominal (Clark)		would increase from 1471 to only 1538 ACFM, well below the 1856 ACFM level. Thus the capacity of the WESP does not appear to be limiting at 2X the normal melting rate.
WESP Condensate RLD-VSL-00004	WESP Drain (Collects all WESP drainage) • 83 kg/hr (15 MTG/d basis) (1) • 52 C (1)		24590-LAW-M4C-20-00001, Rev A	Doubling the melting rate would increase the rate of condensate collection by about 71%, taking into account the constant contribution of steam used in the film cooler. Thus the frequency of pumping collected condensate to PT would increase by less than 71% since other water sources are present. This increase is unlikely to be limiting within the LAW Facility since the increased rate is equivalent to less than 800 gal/hr. Impacts to the PT and ETF/LERF should be evaluated, however.
WESP Condensate RLD-VSL-00005	Total Discharge • 1721 kg/hr (1) • 47 C (1)		24590-LAW-M4C-20-00001, Rev A	
Balancing Damper	• 2556 kg/hr (1) • 1643 ACFM (1) • 53 C (1) • 888 mbar (1) • 82% humidity (1)		24590-LAW-M4C-20-00001, Rev A	The design capacity of the balancing damper can be established to meet virtually any flow/pressure requirement. Thus the damper will not limit melting rate.
HEPA Preheater LVP-HTR-00001A/BA/B	(includes OG from three melters and vessel vent air Vessel Vent Air • 370 kg/hr (1) • 226 ACFM (1) • 33 C (1) • 92% humidity (1) Total to Preheater	• 75 kW maximum heating power (2) • 41 kW maximum heating power (4) • 14.7 psia (2) • 192 F (2)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-WTP-RPT-PT-02-007, Rev 0 (3) 24590-MEC-LVP-00003	The humidity and level of entrained mist that flow to the HEPA Preheaters would be impacted to a very small extent by a doubling of the melting rate. This is because the offgas flow rate to the HEPA Preheater would be increased by only about 5%, a level that would not significantly increase the level of entrained mist. The SBS has sufficient cooling

	• 8039 kg/hr (1) • 5332 ACFM (1) • 865 mbar (1) • 55 C (1) • 71% humidity (1) • 49 kW heating duty (1) • 47 kW heating duty (2)		(4) 24590-WTP-RPT-PT-02-012, Rev 0	power to cool the offgas to the same temperature as under Baseline melting conditions, thereby ensuring the same humidity levels and offgas preheating requirements.
First HEPA LVP-FLTH-00001/4 A/F	• 8039 kg/hr (1) • 5580 ACFM (1) • 861 mbar (1) • 69 C (156 F) (1) • 37% humidity (1)	• 14.7 psia (2) • 192 F (2) • 59 to 113 F dry bulb temperature range for filters and housings (3) • 0 – 100% humidity (3) • 4.42 in W. G. nominal pressure (Royer) • 157 F nominal (Royer) • 35% humidity (Royer)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00003 (3) 24590-WTP-3PS-MKHO-T0001, Rev 1	Specifications for the HEPA filters and housings have been developed. These specifications are general in many respects and depend on establishing application-specific requirements for parameters such as pressure and flow rate. The HEPA systems are not limiting since multiple units can be installed in parallel (stacked) to yield the necessary capacity and meet any conceivable flow rate and pressure drop requirement.
Second HEPA	• 8050 kg/hr (1) • 5612 ACFM (1) • 851 mbar (1) • 67 C (153) (1) • 41% humidity (1)			
Fan LVP-FAN-00001A/B/C	• 8060 kg/hr (1) • 5577 ACFM combined flow (1) • 847 mbar (1) • 62 C (144 F) (1) • 49% humidity (1) • 91% fan speed • 238 mbar delta pressure • 24 kW/fan?	• 33 Hp per fan @ 55% efficiency (2) • 3966 SCFM plus 25% safety factor with 224 mbar delta pressure, 55% efficiency, and 90% motor efficiency, or 75 Hp/fan (3) • 25 kW/fan? (4) • 2955 ACFM max (Royer) • 177 F nominal (Royer) • 89.9 in. W. G. max with 5 in. margin (Royer) • 75 Hp motor rating (Royer)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-WTP-RPT-PT-02-007, Rev 0 (3) 24590-LAW-MAC-LVP-00004, Rev B (4) 24590-WTP-RPT-PT-02-012, Rev 0	Two fans could draw a combined flow of 5910 ACFM (Royer), which is 6% above the nominal flow rate shown in the first column. Thus, the 5% increase in flow at double the melting capacity could just be accommodated by the fan system. Although there appears to be little design margin for the Baseline and 2X melting cases, both the specification and the LAW melter flowsheet are being refined and the final specification and flowsheet likely will demonstrate sufficient design margin to accommodate the 5% higher offgas flow rates at 2X melting rates.

Heat Exchanger (Cold Side) LVP-HX-00001	• 8049 kg/hr (1) • 4615 ACFM (1) • 1078 mbar (15.8 psia) (1) • 81 C (1) • 29% humidity (1)	• 17.3 psia (2) • 773/953 F hot side (2) • 11469 kg/hr (3) • 54 C (3)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00003 (3) 24590-MEC-LVP-00001	The heat exchanger will be sized to meet thermal transfer requirements for heating and cooling the offgas, and likely would have sufficient capacity to accommodate the ~5% increase in flow resulting from doubling the melting rate.
Offas Heater LVP-HTR-00002	• 8049 kg/hr (1) • 9288 ACFM (1) • 1076 mbar (1) • 438 C (820 F) (1) • 0% humidity (1) • 145 kW power requirement (1) • 43 kW power requirement (2)	• 202 kW (3)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-WTP-RPT-PT-02-007, Rev 0 (3) 24590-WTP-RPT-PT-02-012, Rev 0	The offgas heater will be sized to meet thermal transfer requirements for heating the offgas, and the 202 kW capacity appears ample to provide the 5% greater power needed to accommodate the ~5% increase in flow resulting from doubling the melter rate.
Thermal Oxidizer LVP-SCO-00001	• 8049 kg/hr (1) • 9775 ACFM (1) • 1076 mbar (1) • 475 C (1) • 0% humidity (1)	• +22 in. H2O (Tano) (1055 mbar) • 15 in. H2O pressure drop across cat skid (Tano) • 5000 SCFM nominal (Tano) (14170 ACFM at discharge) • 10 # CO/hr max (Tano) • 350 # NO/hr max (Tano)	(1) 24590-LAW-M4C-20-00001, Rev A	Doubling the melting rates would double the rates of CO and NOX evolved from the melter to the offgas stream. This would require doubling the rates of destruction of those species. The CO rate appears to be low and likely can be accommodated by the current catalytic oxidation system. The SCR unit for destroying NOX is already constrained by the high exotheric heat produced in the ammonia and NOX reaction. It is doubtful the vendor will design for more than a 50% margin to account for this heat, unless so directed. Envelope A feeds are worst-case because they will processed at the highest sodium nitrate rates, yielding the highest rates of NOX.
Primary SCR LVP-SCR-00001	• 8320 kg/hr (includes urea injection at 271 kg/hr) (1) • 9011 ACFM (1) • 1071 mbar (1) • 385 C (1) • 0.1% humidity (1)		24590-LAW-M4C-20-00001, Rev A	
Secondary SCR LVP-SCR-00001	• 8333 kg/hr (includes urea injection at 14 kg/hr) (1) • 12360 ACFM (1) • 1062 mbar (1) • 613 C (1) • 0% humidity (1)		24590-LAW-M4C-20-00001, Rev A	

Heat Exchanger (Hot Side) LVP-HX-00001	• 5417 kg/hr (35% of inlet stream is bypassed) (1) • 8178 ACFM (1) • 1049 mbar (1) • 618 C (1) • 0% humidity (1)	• 11966 kg/hr (2) • 515 C (2)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00001	The heat exchanger will be sized to meet thermal transfer requirements for heating and cooling the offgas, and likely would have sufficient capacity to accommodate the ~5% increase in offgas flow resulting from doubling the melting rate.
Caustic Scrubber LVP-SCB-00001	Offgas • 8326 kg/hr (1) • 8187 ACFM (1) • 1047 mbar (1) • 306 C (1) (583 F) • 0.2% humidity (1) Scrubber recycle • 14781 kg/hr (1) • 67 C (1)	• 17.3 psia (2) • 1118 F (short upset)(2) • 310 C nominal (Sentanu) • 600 C max (Sentanu) (1112 F) • -5 to +15 psig pressure range (Sentanu) • 0.5 psig nominal (Sentanu) (1034 mbar) • 5 in. H2O max pressure drop (Sentanu) • 6200 ACFM nominal (Sentanu) • 8200 ACFM max (Sentanu)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00003	The caustic scrubber will be sized to meet mass and thermal transfer requirements for scrubbing residual acids from the offgas, and likely would have sufficient capacity to accommodate the ~5% increase in offgas flow resulting from doubling the melting rate, and the 2X increase in the relatively low concentrations of residual acid gases that must be removed.
Scrubber Bottoms Vessel LVP-VSL-00001	Total discharge • 571 kg/hr (1) • 67 C(1)	• 14.7 psia (2) • 180 F (2)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00003	Doubling the melting rate will double the rate of acid gases and CO2 that must be processed in the scrubber. This could result in increasing the rate of generation of scrub solution by up to a factor of 2X, but even doubling the relatively small quantities generated should be well within the capacity of the vessel and pumping system.
Offas Heater LVP-HTR-00002	• 9135 kg/hr (1) • 5628 ACFM (1) • 1034 mbar (1)	• 100 kW maximum heating power • 400,100 Btu/hr (2)	(1) 24590-LAW-M4C-20-00001, Rev A	The heat exchanger will be sized to meet the thermal transfer requirements to heat the offgas, and likely will have sufficient

	• 68 C (1) • 100% humidity (1) • 65 kW power requirement		(2) 24590-WTP-RPT-PT-02-012, Rev 0	capacity to accommodate the ~5% increase in offgas flow resulting from doubling the melting rate.
Carbon Column LVP-ADBR-0000X	• 9135 kg/hr (1) • 5991 ACFM (1) • 1028 mbar (1) • 88 C (1) • 44% humidity (1)	• 13450 #/hr (Pease) • 167 F max (Pease) • 12 in. H2O pressure differential Pease) • 11.2% humidity max. (Pease)	24590-LAW-M4C-20-00001, Rev A	The carbon column is being relocated after the HEPA filters. Doubling the melting rate would double the rate of acid gases, mercury, and I-129 that must be removed by adsorption onto the carbon. This likely would result in doubling the rate of generation of spent carbon and the frequency of carbon changeout. However, it would have a negligible impact on the offgas treatment system because a redundant column could be valved into service during carbon change-out of the loaded column.
Stack	• 9124 kg/hr (1) • 5992 ACFM (1) • 992 mbar (1) • 76 C (1) • 69% humidity (1)	• 17.3 psia (2) • 572 F (2)	(1) 24590-LAW-M4C-20-00001, Rev A (2) 24590-MEC-LVP-00003	The stack will be sized to meet applicable environmental discharge requirements, and likely would have sufficient capacity to accommodate the ~5% increase in offgas flow resulting from doubling the melting rate.

A.4 HVAC and Electrical System

A.4.1 Background

The following summarizes the review of the HVAC and electrical system current design capabilities with respect to their ability to support an increase in melter production rate in excess of the baseline of 15 MTG/day per melter. This review focused on the pour caves and finishing line HVAC systems and the overall electrical system. This review estimates peak capacity limits based on the current design of these systems. The review to-date has not considered system availability to establish average production rates.

The design of these systems was not complete at the time of this review. Significant redesign of some of these systems was underway as this review was being conducted to accommodate the change from three to two melters in the LAW facility and to a significant change that was made in the assumed thermal properties of the glass that increased the heat loads in the pour caves and the finishing lines. The review was, therefore, based on data available in existing and developing calculations, system descriptions, specifications, etc. and on discussions with BNI design personnel. The sources are listed as references in the following discussion. The results of the discussions with BNI are summarized in Appendix B of this report.

The following provides discussion on the following factors in the LAW HVAC and Electrical systems that have the most limiting impact on the achievable peak glass production rate for the LAW facility:

- Pour Cave and Canister Temperatures
- Pour Cave Ventilation and Cooling
- Pour Cave Cooling Panels
- Finishing Line Temperatures
- Canister Transfer Temperatures
- Melter Cooling
- Melter Power Supply Cooling
- Electrical System including the Melter Power Supplies

Table A.4-1 summarizes the design requirements and current specified capacities for the several components that comprise the LAW HVAC and Electrical systems. These are preliminary data and were used to support the discussion and conclusions drawn in the following.

A.4.2 Pour Cave and Canister Temperatures

There are several limits on pour cave temperatures that must be met by the pour cave cooling and ventilation systems during normal operation. These are limits on the structure temperatures, principally the concrete (150 °F), ambient temperature (200 °F), HVAC exhaust temperature (150 °F) and the temperature of the canister for handling (600 °F) [1]. During normal operation the ability of the cooling panels and ventilation system to maintain these temperatures below limits is dependent on the rate at which the canister is filled and exported from the pour cave, the properties of the glass and the glass melt temperature. Computational Fluid Dynamic (CFD) calculations performed by Bechtel, San Francisco [1] determined these parameters for normal operating as well as off-normal operating and loss-of-power conditions in the pour cave.

In these analyses the bounding pour cave evaluations for normal operation are based on a continuous pour scenario of 4 partial pours over a 9 hour period with a 1 hour hold after the last pour. The total canister residence time in the pour cave was 28 hours including 10 hours in the pour position, 10 hours in the cooling position and 8 hours in the transfer position. The calculated concrete temperatures are well below maximums for a glass pour temperature of 2100 °F and the 10 hour pour time. The maximum ambient air temperature is well below maximum (149 °F versus maximum allowed of 200 °F) and the maximum HVAC exhaust is 145 °F versus a maximum allowable of 150 °F. (Note that the more limiting conditions for ambient and structural temperatures are the off-normal and loss of power conditions. These are not considered herein because they are not relevant to the peak capacity of the system under normal operation.) The maximum canister skin temperature (760 °F), however, exceeds the maximum handling temperature (600 °F) during the pour cycle. Based on the CFD calculations, the container skin temperature remains above the maximum handling temperature for 30 hours after the initiation of the first pour.

These calculations are conservative in several areas:

- Three "steel beam" cooling panels were not included in the modeling
- Conservative air flows and temperatures were used.
- The turntable and its cooling circuits were not modeled.
- Bounding glass properties, including high thermal conductivity, were used.

The impact of exceeding the 600 DegF maximum handling temperature while on the elevator during pour and then when on the carousel in the cooling and transfer positions is not known. It is assumed, however, that it would not be possible to move the canister out of the pour cave into the transfer tunnel until the skin temperature is below 600 DegF. For the bounding high conductivity glass property condition this would require that the canister remain in the pour cave for at least 30 hours prior to transfer. It is understood that the current BNI baseline timeline assumes that a canister remains in the pour cave for 48 hours from the beginning of the first pour. This includes 10 hours in the pour position, 20 hours in the cooling position and 18 hours in the transfer position. In this timeline it is assumed that the exchange of the filled canister in the transfer position with a new canister takes up the 2 hours difference in time while in the cooling and transfer positions. The 20 hours in the cooling position includes 10 hours pouring in the same pour cave and 10 hours pouring in the opposite cave. The 48 hour period is required to reduce the canister heat release rate sufficiently to enter the finishing line. [1, 2] This timeline supports a facility peak production rate of 4.8 canisters or 28.8 MTG a day (two melters, four pour caves at 10 hours per alternating pour per cave, 6 MTG per canister [2 melters x 24 hours per day/10 hours per canister per melter x 6 MTG per canister = 28.8 MTG/day])

Assuming that the 600 DegF handling temperature is a limitation on moving the canister out of the pour cave and it takes 30 hours for the canister to reach that temperature, then it appears that this timeline could be reduced by 18 hours. This timeline would support a pour period of 7.5 hours, 15 hours in the cooling position and 7.5 hour in the transfer position. This assumes a total time of 7.5 hours in the transfer position – moving the filled canister out and the new canister in. This would support a facility maximum production rate of 6.4 canisters or 38.4 MTG per day. [2 melters x 24 hours per day/7.5 hours per canister per melter x 6 MTG per canister = 38.4 MTG/day]

This shorter time line is not consistent with the pour cave CFD analyses although the total time frame is in the same order (30 hours versus 28 hours). The peak temperatures and heat capacity of the canister in the pour position will be higher for the shorter total pour period (7.5 hours versus 10 hours). It is likely that the structural, ambient and HVAC exhaust temperatures would still be acceptable based on the significant margin to the maximums in the current analyses and the fact that the overall heat release would be similar. Peak skin temperatures would be higher because of the shorter pour time. This timeline is considered representative of the maximum production rate that could be achieved based on not exceeding the maximum canister handling temperature with the current design pour cave cooling and ventilation capacities.

Increased air flow rates and reduced air temperatures (or other means such as supplemental cooling packs that would be positioned around the canister) could be used to reduce the skin temperature sooner. However, these must be sustained through the transport of the canister out of the cave. The heat release rate is essentially independent of the outer temperature because of the insulating properties of the glass itself, and the sooner the canister leaves the pour cave the higher the release rate. As discussed more below, an interval of 48 hours is currently estimated as required to reduce the canister heat release rate to a value that can be accommodated by the finishing line ventilation system. It is also understood that it is not feasible to increase the capabilities of the HVAC systems which are currently at the maximum achievable for the current facility footprint and configuration.[3] It is possible that the canister buffer area could be used to allow the canister to cool to an acceptable temperature prior to being transferred to the finishing line if the canister were moved to the buffer area in a temporary cooling pack. In any event this is not the current baseline and considerable design work and modification would be required to achieve faster skin temperature reductions. The maximum capability of the buffer area to temporarily store canisters as they cool has not been established. The buffer area was not intended for this purpose. [4]

Accordingly, it is estimated that requiring the canister to be cooled to a skin temperature no higher than 600 °F prior to handling, limits the current facility peak production rate to 38.4 MTG/day. Note that the required times for cooling to an acceptable temperature for handling could be reduced if future measurements show that the assumed glass properties are overly conservative. These measurements will be complete in the Fall 2003. [5] BNI indicates that the CFD analyses will be redone when the results of these measurements are available and the timing limits will be established. [4]

It should also be noted, if the pour temperature were increased as part of increasing the melter efficiency the times to cool may be longer and reduce the production rate. If the pour temperature were increased, supplemental canister cooling may have to be investigated to take advantage of the improved melter efficiency.

A.4.3 Pour Cave Ventilation

The CFD calculations [1] assume air flow rates through each pour cave that total 7720 cfm at varying temperatures depending on the source, e.g., 6150 acfm at 113 °F from the transfer tunnel is the principal flow. The calculations for sizing the LAW C5 Exhaust Fan [reference Calc No. 24590-LAW-MAC-C5V-00001, Rev 1] show pour cave flowrates in the range 5895 scfm to 6396 scfm In and 7575 scfm to 8075 scfm Out depending on the status of the CO_2 decontamination systems which extract 2000 scfm of makeup air from C5 upstream of the pour caves when operating. It is understood from discussions with BNI personnel [3] that the sizing calculation reflects the results of the latest pour cave and finishing line CFD analyses (referenced above) which, as noted above, consider the current "bounding" glass properties and the two LAW melter configuration. The reduction in the number of melters from 2 to 3 permitted redirecting ventilation flow from the 5th and 6th caves to the other four maintaining overall flow requirements similar to the last analyses. The current flow requirements did increase the required fan motor size from 250 to 400 horsepower.

It is understood that without significant redesign and innovation (e.g., locating additional fan units in the pour caves for the third melter) that there is no space available in the facility for additional fan units, including the fans, motors, coolers and filters. [3] The ability to accommodate increased throughput in the pour caves from the standpoint of ventilation, therefore, depends on the inherent margins applied in the design process which, based on discussions with BNI personnel, [3] are in the range of 15% on heat load and 20% on static pressure, and the conservatisms in the CFD calculations. As noted above, one of the more significant unknowns in the CFD calculations are the glass properties. Once these are better defined in the Fall 2003, the actual available margins between the calculations and the design capabilities can be determined.

As noted above the CFD analyses show significant margin in the calculated temperatures versus the limits. Considering this fact and the design margins discussed above, for the purposes of this analysis it will be assumed that the ventilation systems have sufficient margin to support a 25% increase in melter throughput, i.e., from a current nameplate rating of 30 MTG/day to 38 MTG/day.

A.4.4 Pour Cave Cooling Panels

Maintaining pour cave air and structure temperatures within design limits is accomplished though a combination of ventilation and strategically placed cooling panels. The pour cave cooling panels were originally designed to be supplied with chilled water as the heat sink. [3] In September 2002 a change in the estimates for glass parameters resulted in significant increases in the heat loads in the pour cave and finishing line requiring increases in the capacity of the water cooling and HVAC systems supporting these areas. The increase in heat loads due to the change in glass properties had a major impact on the design of the pour cave water cooling system. The increased loads required an increase in the number of cooling panels in the pour cave and strategically locating the new panels in critical areas. BNI also concluded that it would be more economical to cool the system with plant cooling water (system PCW) rather than chilled water (CHW). [1, 3]

The interface with the BOF plant cooling water system is at the pour cave cooling panel heat exchangers (PCW-HX-00019A/B). The cooling panels are supplied with demineralized water in a closed loop system using these heat exchangers as the heat sink in that loop. These are plate and frame heat exchangers and specified with typically 15% margin on heat load. The specification for the heat exchangers also requires that provision be made for addition of 25% to 50% more plates [reference Specification No. 24590-WTP-3PS-MEP0-T0001, Engineering Specification for Plate and Frame Heat Exchangers]. According to BNI, the addition of plates to an heat exchanger that has been in service is straightforward. Additionally, the piping for the cooling water supply from BOF was sized to accommodate three melters at a nameplate rating of 15 MTG/day each so additional cooling water could be provided in the future, if required. [2, 3, 6]

The maximum heat load on an individual panel depends on its location. Each panel is designed for the maximum load and the heat exchangers are designed for the combination of these loads. However, the panels are not necessarily all exposed to the maximum heat load simultaneously. During the pouring, cooling and export sequence within an individual pour cave the cooling panels will be exposed to their maximum heat loads at different times in the sequence. There is, therefore, inherent margin in the capacity of the pour cave cooling heat exchanger design. It is noted, however, that the critical requirement of this system is to limit pour cave structural temperatures below maximum operating limits. This depends on the capability of each panel at its maximum load.

The layout of the cooling panels was reviewed briefly. It is understood that the majority of the pour cave surfaces are covered by cooling panels and that there is little space available to add panels to increase the cooling capacity in that area. [3] It was pointed out by BNI that an increased heat load in the area, (e.g., if the melters were operated at higher throughput than the current baseline such as 22 MTG/day versus 15

MTG/day) would result in an increase in the cooling water differential temperatures and a small increase in the structural and air temperatures which BNI personnel consider would be within the capabilities of the SSC specifications for modest increases in throughput.

It is concluded, therefore, that the capacity of the pour cave cooling panels and the heat exchangers that remove the heat from the cooling panels are not limiting with respect to an increase in melter throughput. The combination of the cooling panels and the ventilation system in the pour caves are, therefore, considered to be capable of accommodating the increase of 25% as stated above.

A.4.5 Finishing Line Temperatures

The finishing line temperatures were also calculated in the CFD analyses [1]. The C5 exhaust fan sizing calculation also considered the heat load in the finishing line based on these calculations [7]. Two different timelines were evaluated in the CFD analyses – a "fast" schedule and a "typical" schedule. The fast schedule assumes the container leaves the pour cave 28 hours after the first pour. The typical schedule assumes the container leaves the pour cave 48 hours after the first pour. Calculations were also made with varying glass thermal conductivities to bound the heat release and skin temperatures in the finishing line as a function of time. These calculations established required ventilation flow rates which were then used in the fan sizing calculation.

The C5 fan calculations use the heat release rates from the CFD analyses, the same residence times at each stage in the finishing line and the "typical" pour cave schedule, i.e., the canister enters the finishing line 48 hours after the start of the first pour. [7]. The calculations indicate that this is the minimum time after the initial pour that the canister can enter the finishing line without exceeding allowable temperatures in the line. [2, 4] Based on discussions with BNI [3] it is understood that there is a limit on the maximum canister temperature to enter the inerting/sampling/welding position. This may change if the welded lid is changed to a crimped lid. [4] In any event the 48 hour timeline results in a calculated maximum canister skin temperature of about 460 °F when entering the finishing line.

The 48 hour interval prior to entering the finishing line is consistent with the current pour cave timeline that includes 10 hours in the pour position, 20 hours in the cooling position and 18 hours in the export position. As noted this is consistent with a production rate of 4.8 canisters or 28.8 MTG per day. To meet the higher production rates discussed above, e.g., a 30 hour pour cave timeline that results in a 6.4 canister or 38 MTG per day production rate, the canisters would have to spend 18 hours in the buffer area to cool to the required temperature prior to entering the finishing line. Note that there is uncertainty on the ability of the buffer area ventilation to accommodate the heat load for canister cooling over this time frame. [4]

The calculations assume that a canister is resident in every station in the finishing line and, assume a canister enters the line every 8 hours [7]. The calculations, therefore, are consistent with a facility peak production rate of 6 canisters per day or 36 MTG/day [3 canisters per day per line x two lines x 6 MTG per canister = 36 MTG/day].

A.4.6 Transfer Temperature

The CFD analyses [1] provide calculations of the canister centerline and surface temperatures versus time for two canister fill and finishing timelines. The fast timeline results in completing canister processing to the point where it is ready to be transferred to DOE within about 43 hours from the start of the first pour. For this scenario the peak canister surface temperature at transfer is about 530 °F. The longer, typical timeline results in completing canister processing in about 63 hours with a peak canister surface temperature of about 440 °F. The Contract [reference 1, Specification 2, 2.2.2.13, External Temperature] states that "The temperature of the accessible external surfaces of the package shall not exceed 465 °F (alternating pour) or 550 °F (single pour) when returned to DOE." The CFD analyses were performed for single pour conditions so the Contract limits are met for either the 43 hour or 63 hour time period. In the alternating pour mode, however, it is not likely that a period significantly shorter than 63 hours could be used without exceeding the limit. Meeting the canister temperature limit for export is not limiting the production capacity considering the other limits on canister heat release rate that must be met to enter the finishing line.

A.4.7 Melter Cooling Water

The melter cooling panels are supplied by a closed loop circuit using demineralized water and heat exchangers PCW-HX-00004 A/B and 00005 A/B as the heat sink. The heat exchangers are supplied with plant cooling water from the balance of plant system at a nominal inlet temperature of 79 °F. (Note that the balance of plant is designed to supply plant cooling water at 77 °F. The heat exchanger sizing calculations include a 2°F margin on inlet temperature.) The flowrate requirements are set by Duratek and are based on calculations and experience with the pilot melter for a nominal melter throughput of 15 MTG/day. [8] According to the Duratek calculation there is no margin in the specified flowrates and heat loads. Review of the heat exchanger and pump specifications against the specified requirements [Table A.4-1] indicates typical design margins for the pump, 5 gpm on flow and 10 psi on total developed head [TDH] but considerably higher margin (e.g.,up to about 50%) in heat exchanger capacity. BNI indicates, however, that the specifications for the heat exchangers are still under development and the actual margins are not currently defined. The BNI design criteria specify a design margin of 15% on heat exchanger design [10], 10% margin on pump capacity. [3] BNI also assumes that the cooling water inlet temperature is 2 °F higher than design which adds another 5% to 10% margin depending on the cooling water differential temperature. On this basis, therefore, a minimum margin of about 35% in heat removal capability for this system could be expected [0.15 + 0.1 + 0.1].

The melter cooling heat load is essentially independent of the throughput of the melter for the same melt temperature and the same melter area. The melter cooling panel system requirements would, therefore, not be different than the current design under these conditions. Duratek indicates, however, that some increases in melter throughput would occur as a result of increasing the melt area by reducing the thickness of the refractory, and increasing the glass temperature. [9] If these changes were made the panel cooling requirements will be increased.

According to BNI calculations [reference calc 24590-LAW-ETC-LMP-0001] the heat loss for an increase in melt temperature is most limiting under idling conditions (principally because of the loss of the cold cap). This loss has been assumed by BNI to be a linear function starting with zero heat loss at 45 °C room temperature and the value cited by Duratek at 1150 °C. This results in the following expression for heat loss versus melt temperature – $Q_{SS}(T)$, kW = 12.372 (T °C/45 –1). This same calculation shows that the heat loss to the cooling panels in the idling mode is about 62% of the total heat loss. On this basis the increase in heat load on the cooling panels for a 50 °C increase in melt temperature would be about 8.5 kW out of a total of about 130 kW or 6.6% [62% x 12.372 kW per °C / 45 °C x 50 °C increase = 8.3 kW].

The increase due to a reduction in refractory thickness can be estimated using data provided by Duratek for the effect of refractory corrosion over the melter lifetime [8]. For a six-inch loss of refractory Duratek indicates the cooling panel heat load at a constant melt temperature of 1150 °C would increase by 32% in the feed mode and 24% in the idle mode. A 6-inch reduction in refractory thickness increases the melt area by 23% [(Current Melt Pool Length 16.167 ft + 1 ft) x (current melt pool width 6.667 ft + 1 ft) /(16.167 x 6.667) = 1.23] On a per unit basis the ratio of cooling panel heat load increase for a decrease in refractory thickness is 0.32/6 = .0533 per unit per inch reduction. The Duratek discussions indicate that the melt area could be increased by 30% without affecting the footprint of the melter. An 8 – inch reduction in refractory thickness is required to obtain a 30% increase in melt pool area. The 8-inch reduction in thickness will increase the heat load by 42.7%. [0.0533 per unit/ inch x 100 % per unit x 8 inches = 42.7 %].

The combination of these two changes in the melter could increase the cooling panel heat load by up to 49% [6.6 % due to temperature increase + 42.7 % due to reduction in refractory thickness]. Based on current data the cooling panel margins are in the range of 35% so assuming all cooling criteria remain constant it would not be possible to accommodate the full range of the temperature and refractory changes. Assuming the effects are linear 35/49 or 71% of the changes could accommodated. According to Duratek these changes would result in a 50% increase in throughput. The cooling panel capacity may limit that to 35% or 5 MTg/day. This would support the target goal of 40 MTG/day.

A.4.8 Melter Power Supply Cooling

In the current design, the melter power supplies and the electrical buses are cooled by a closed loop circuit using demineralized water and heat exchangers PCW-HX-00007 A/B as the heat sink. The heat exchangers are supplied with plant cooling water from the balance of plant system at the nominal temperature of 77 °F. The current design includes three power supplies with no separate auxiliary or backup supply. [3] The backup supply is built into the primary supply. The current calculations are based on supplying cooling for the power supplies and buses of the original three melter configuration. [reference calculation 24590-LAW-MEC-PCW-00001] The number of power supplies will be reduced to two – one for each melter – and the cooling system will be downsized accordingly. [3] The pump sizing calculation [reference 24590-LAW-MPC-PCW-00001] includes 35% margin in flowrate to accommodate required minimum flow recirculation and some margin. The heat exchangers include a 15% margin on heat transfer area. The BNI HVAC design criteria include a 15 % design margin. Since the design of this system for the two melter configuration has not been completed, it will be assumed that this system has a 15 % design margin. This is conservative based on the design work for the three melter configuration.

It is understood that a Trend has been submitted to cool the buses with forced air ventilation rather than water. If this change is made it would reduce the overall heat load requirement on the heat exchanger. The same design margins would, however, be retained. Accordingly, this change would not affect the conclusions of this evaluation.

Table A.4-1 summarizes the results of recent LAW pilot melter tests. This table documents the actual power required to produce glass at the rates indicated for ranges of feed conditions for waste envelopes A, B and C. On a gross average basis this indicates a power requirement of about 65 kw/MTG/day. This includes the process power (power to melt the slurry) and the conduction and ventilation heat losses. From prior work the process power requirement was estimated at 55 kw/MTG/day [reference calculation 24590-LAW-ETC-LMP-00001]. It is stated in this calculation that this rate was based on a feed rate of 2.2 MTG/m^2/day which is similar to those summarized in the table. The net power requirement of 10 kw/MTG/day covers the heat and ventilation losses. This is lower than stated in the prior calculations of power requirements [calculation reference above] which cites heat losses of 212 kW and ventilation losses of 80 kW. This load, however, does not change with throughput.

Discussions with BNI personnel indicate that a continuous rating of 1430 kW will be specified for the melter power supplies. [11] Using the process power requirements and the heat loss requirements this would support a glass production rate of (1430 kW – 292 kW losses) / 55 kW/MTG/day = 20.7 MTG/day per melter or 41.4 MTG/day for the facility.

Accordingly, the cooling systems should be capable of supporting a sustained average throughput 15% greater than current design or about 23.8 MTG/day per melter or 47.6 MTG/day for the facility. The melter power supply cooling system is, therefore, not limiting with respect to meeting Contract requirements or the DOE-ORP stretch target goal of 40 MTG/day

feed type	avg specific throughput during feeding periods, MTG/m2d	total for pilot melter, MTG/d	max pilot (highest power spike) kW	projected for 10 m2 melter (production unit)	LAW melter power = 3 x pilot, kW	R&T data reference
Env A1 nominal	1.97	6.5	380	20	1140	TRR-PLT-71
Env A1 15 % low waste variation	1.89	6.2	415	19	1245	TRR-PLT-71
Env A1 15 % high waste variation	1.66	5.5	380	17	1140	TRR-PLT-71
Env A2 nominal	1.30	4.3	360	13	1080	TRR-PLT-70
Env A2 15 % low waste variation	1.40	4.6	370	14	1110	TRR-PLT-70
Env A2 15 % high waste variation	1.80	5.9	380	18	1140	TRR-PLT-70
Env C1 nominal	1.80	5.9	390	18	1170	TRR-PLT-69
Env C1 15 % low waste variation	1.80	5.9	370	18	1110	TRR-PLT-69
Env C1 15 % high waste variation	1.70	5.6	390	17	1170	TRR-PLT-69
Env C2 nominal	2.20	7.3	420	22	1260	TRR-PLT-72
Env C2 15 % low waste variation	2.00	6.6	420	20	1260	TRR-PLT-72
Env C2 15 % high waste variation	2.10	6.9	425	21	1275	TRR-PLT-72
Env B1 nominal	2.21	7.3	450	22	1350	TRR-PLT-74
Env B1 low waste variation	2.02	6.7	460	20	1380	TRR-PLT-74
Env B1 high waste variation	2.07	6.8	450	21	1350	TRR-PLT-74

A.4.9 Electrical Systems

The LAW facility is not limited by available normal electrical power supply. The switchgear is conservatively designed to be able to accommodate higher electrical loads (13.8 KV with a continuous rating of 1200 amps). The LAW facility electrical load summary assumes that the electrode power supplies operate continuously at their ratings. The facility electrical load design is, therefore, not limiting.

The margin in standby electrical power for the melter is not known. The standby power requirement would increase for the larger area and reduced refractory thickness and, possibly, the higher operating temperatures that may be part of increased production capacity of the melters.

As noted in the discussion on melter power supply cooling the current design specifications for the power supplies will support a sustained melter glass production rate of 20.7 MTG/day or 41.4 MTG/day for the facility. This is adequate to meet the Contract requirements and the DOE-ORP extended target goal of 40 MTG/day.

A.4.10 References

1. Calculation 24590-LAW-M4C-C5V-00001, CFD Analysis of LAW Pour Caves (with additional cooling) and Finishing Lines, Rev A, 3/28/03

2. Appendix B, BNI response to Question 2, Section F

3. Report of Meeting, May 13, 2003, a copy is included in Appendix B of this report

4. Report of Meeting, June 13, 2003, a copy is included in Appendix B of this report

5. BNI Memorandum CCN 036415, Assessment of Glass Thermal Property Literature, July 3, 2002

6. ORP Memorandum 03-AMWTP-001, Modifications to the Low Activity Waste (LAW) Facility Implementation of the 2+2 Melter Trends, January 22, 2003

7. Calculation 24590-LAW-MAC-C5V-00001, LAW C5 Exhaust Fan Sizing, 4/10/2003

8. 24590-101-TSA-W000-0010-409-359, LAW Melter System Description, Duratek REP-WTP-11000, Revision 0, November 2002

9. Duratek Memorandum, Government Owned – LAW Pilot Melter Decommissioning and Testing Proposal, May 1, 2003

10. Calculation 24590-LAW-M0C-G40T-00001, HVAC heating and Cooling Load Calculations General Design Criteria, Revision 1, 11/30/01

11. Telecon with Rich Peters of BNI on June 17, 2003

Table A.4-1
Summary of HVAC and Electrical System Component Design Requirements and Capacities

Component	Requirement	Design Capacity	References	Comments/Discussion
LAW Plant Cooling Water (PCW)				
Melter Cooling Water and Monitor (P&ID 24590-LAW-M6-PCW-00003—Melter 1)				
PCW-PMP-0010 A/B	275 gpm [1] 250 gpm, 90 psi TDH [2], (5 gpm and 10 psi margin)	300 gpm, 93.3 psi TDH [3]	4. 24590-LAW-MEC-PCW-00002, Rev A 5. 24590-LAW-MPC-PCW-00002, Rev A 6. 24590-LAW-MPD-PCW-00003	Requirements are set by Duratek in LAW Melter System description 24590-101-TSA-W000-0010 and Melter Interface Document 24590-LAW-MID-M-01-001 (this was identified as a reference in the other documents. It is not available on the ORP version of BNI DocSearch.
PCW-HX-00004A/B	1,241,850 Btu/hr [1], includes pwr supply heat load 1,418,000 Btu/hr [2], based on Duratek flowrates	1,865,000 Btu/hr [3] These heat exchangers appear to be conservatively specified.	2. 24590-WTP-RPT-PT-02-012, Rev0 3. 24590-LAW-MEC-PCW-00002, Rev A 4. 24590-LAW-MED-PCW-00001, Rev B	This heat exchanger principally supplies the external cooling panels on the melter. The load on this heat exchanger does not increase significantly as the flow through the melter increases. The principal increase will be an increase in heat generation in the electrodes and feed piping.
PCW-EVAP-00001				No information available on ORP version of BNI DocSearch This has been deleted from the facility design
PCW-VSL-00009				Not reviewed
PCW-VSL-00010				Not reviewed
PCW-VSL-00020				Not reviewed
Plant Cooling Water System Melters Power Supply Cooling (24590-LAW-M6-PCW-00002)				
PCW-PMP-00013 A/B	556 gpm, req'd, 135% margin applied for min recirc and margin., 113 psi TDH with 20% margin	550 gpm, 75 psi TDH [2]	3. 24590-LAW-MPC-945-00001, rev A 4. 24590-LAW-MPD-PCW-00001	It appears that these pump calculations and specifications do not reflect the reduction in the number of LAW melters. This will be revised in the final design of the facility.
PCW-HX-00007 A/B	5,800,000 Btu/hr [1], sized for three melters	4,090,000 Btu/hr [2], appears to be specified for 2 melters.	1. 24590-LAW-MEC-PCW-00001, rev A 2. 24590-LAW-MED-PCW-00003	Need to establish if the specification is for 2 LAW melter configuration and obtain the updated basis calculation. According to BNI the heat exchanger specification is for 2 melters. The system

Component	Requirement	Design Capacity	References	Comments/Discussion
				design has not been completed and this is preliminary data.
PCW-EVAP-00004				No information available on ORP version of BNI DocSearch This component has been removed from the facility design.
PCW-VSL-00018				Not reviewed
PCW-VSL-00019				Not reviewed
PCW-VSL-00023				Not reviewed
Pour Cave Pipe Manifold (P&ID 24590-LAW-M6-PCW-00009, 3 shts) Melter 1				
BOF PCW supply	Heat Load calculated as 7,709,693 Btu/hr with a hot side flowrate of 1902 gpm at 88 DegF for three melter operation. Calculation of required PCW supply to pour cave panels has not been identified			CFD calculations obtained from BNI
C5V-HX-xxxxx 26 panels plus the *carousel identified on* P&ID			1. P&ID 24590-LAW-M6-PCW-00009, Rev 0 (3 sheets)	No calculations available in ORP version of BNI DocSearch CFD calculations were obtained from BNI
LPH-TTBL-00001 and 00002				
Chilled Water (CHW)				
SBS Chilled Water Heat Exchangers				

Component	Requirement	Design Capacity	References	Comments/Discussion
CHW-HX-00003 A/B	6,322,500 Btu/hr based on three melters [1]	4,125,000 Btu/hr [2]	1. 24590-LAW-MEC-CHW-00002, rev A 2. 24590-LAW-MED-CHW-00003	The heat exchanger appears to have been specified for two melters The system design is not complete. The heat exchangers will be sized for 2 melters.
CHW-PMP-00004 A/B	Cold Side 870 gpm based on three melters [1] Supply side 971 gpm [1]	951 gpm, 82.3 psi TDH [2]	1. 24590-LAW-MEC-CHW-00002, rev A 2. 24590-LAW-MPD-CHW-00003	The pump appears to be sized for 3 melters. If the pump is to be resized for 2 melters needs to be determined. The pump will be sized to support 2 melters.
Chilled Water Supply to Area Coolers				
				Data not identified.
		Ventilation		
Pour Cave Cooling				
Supply Air	Tunnel supply -- 3700 CFM at 113 DegF C3 Supply – 800 CFM at 55 DegF			Requirement based on presentation in Design Review Meeting June 27, 2002 BNI provided the C5 fan sizing calculations – see discussion in main body of report
Finishing Line				
Heat Load/Air requirements	2,400 cfm at 55 DegF [1] 78,157 Btu/hr [2]	Colmac Coils at 57,000 Btu/hr each (5 total) Rooms L-0127, L-0133, L-02113, L-0126A and L-0132A No mech data sheets for cooling coils found in ORP version of BNI DocSearch.	1. CALC-W375LV-HV00025 2. 24590-LAW-MAC-C5V-00002, rev A	The first reference is a BNFL calc that should be superseded by a BNI calc. Assumes 3 canisters are resident in the finishing line at one time. The second reference sizes the Finishing line cooling coils. A figure in this calc references the BNFL calc. BNI provided CFD calculations and the C5 fan sizing calculations – see discussion in main body of report

Component	Requirement	Design Capacity	References	Comments/Discussion
C5 Exhaust Fan Air Flow	4 pour cave @ 3,700 cfm 4 finishing lines @ 2,400 cfm Total –24,400 cfm	52, 439 ACFM @ 59 DegF 62, 908 ACFM @ 161 DegF [1]	1. 24590-LAW-MAD-C5V-00006	Fan is likely sized for 6 pour caves and finishing lines BNI provided the C5 fan sizing calculations – see discussion in main body of report
			Electrical	
Melter				
Electrodes	Sized for 22 MTG/day, based on 30% design calcluatons 1491 KW main 425 standby [1] Normal 883 to 1622 KW Standby – 425 KW [2] Normal, Env A, B and C, 1137, 1147, 1191 kW Standby – 550 kW [3]		1. 24590-LAW-ETC-LMP-00001, Rev A 2. Design review meeting June 27, 2002 3. 24590-101-TSA-W000-0010-4090359, 12/02	The first reference was based on 30% Duratek design calculations The second reference is more recent. The basis for the data, e.g., the production rate of the melter is not known. The third reference is the latest Duratek system description. It appears to increase the standby diesel power requirements for an idle melter.
Power Supply		2000 kVA	1. LAW Electrode Single Line Diagram, Melters and Melter Offgas Design Overview, June 27, 2003	
Switchgear		13.8 kV, 1200 amp continuous rating	1. 24590-LAW-ESD-MVE-00017	
LAW Facility				
Total Load	17,250 kW connected 12,232 kW Operating [1]		1. 24590-LAW-E1C-MVE-0001	This calculation assumes that each melter electrode power supply is operating continuously at 1900 kW. This is conservative by 60% to 67% depending on the envelope when operating. This electrical load summary has been revised for the two melter configuration.

A.5 Material Handling

The following summarizes the assessment of the maximum capacity of the LAW facility finishing lines and export bay. The times for handling of empty canisters to prepare for insertion into the pour caves is not limiting and is not covered below.

A.5.1 Finishing Line Capacity

The CFD calculations are based on the following residence times (hours) in each station [C5 fan sizing calculation, reference 7, Sheet A7-7]:

Lidding	5.2
Decontamination	3.3
Export	3.05
Airlock	0.25
Total time in finishing line	11.8

These are a little different than what is understood to be the current sequence based on the CFD calculations and discussions with BNI [3]:

Lidding	5.5
Decontamination	3.5
Swabbing	2.75
Export	0.25
Total time in finishing line	12.0

The principal difference appears to be nomenclature but the total times are similar. Based on these sequences the most limiting station is the lidding/welding station at 5.5 hours. Theoretically, therefore, the finishing line could process a canister every 5.5 hours or 4.4 canisters per day per line [24 hours per day/ 5.5 hours per canister = 4.4 canisters per day]. This would be equivalent to a facility production rate of 8.8 canisters or 52.8 MTG per day. The heat load calculations may support this throughput assuming that each canister would be held up in the buffer area to assure an interval of 48 hours from initiation of its first pour prior to entering the finishing line. This would require a pour time of 5.5 hours with a total residence time in each pour cave of 22 hours and 26 hours in the buffer area. At full capacity the buffer area would have to accommodate about 10 canisters.

It is not known whether the buffer area can accommodate this many canisters and if the HVAC system in the buffer area is sized for that capacity. [4] The residence time in the pour cave is not sufficient to reduce the canister temperature to the 600 °F handling limit The pour cave temperatures would also be higher than currently calculated by the CFD analyses and a re-analysis would be required to establish if the cooling systems would support this rate. However, narrowing the review to the finishing line only the current ventilation calculations may support the full capability of the line, i.e., 8.8 canisters or 52.8 MTG per day.

A.5.2 Transfer to DOE

The process for transfer of the completed canisters from WTP to DOE for burial has not been finalized. Based on the original design a period of 6.6 hours was estimated to transfer a canister from the airlock to the DOE trailer for transport to the burial site.[Reference 24590-LAW-RPT-ENG-01-001, rev 0, 9/12/2001] In subsequent discussions with BNI this time was considered to be excessive and not reflective of the current design, e.g., the new design does not include the container storage facility. A time of 4.5 hours was considered reasonable and meets the current contract requirements. There is only one truck bay and crane for this purpose in the current design of the facility. Accordingly, the peak capacity of the export bay is 5-1/3 canisters or 32 MTG/day [24 hours per day/4.5 hours per canister x 6 MTg per canister = 32 MTG/day]. This is the most limiting area of the facility with respect to production of glass. It is considered that relatively straightforward changes changes could be made in the process to streamline the administrative areas of the transfer and reduce the total time significantly so that this process is not limiting the production rate of the facility.

Appendix B

BNI Responses to
ORP Technical Design Oversight Questions
LAW Melter Support Systems

Appendix B

BNI Responses to
ORP Technical Design Oversight Questions
LAW Melter Support Systems

The following questions (lines of inquiry) were developed by ORP as part of the design oversight of the BNI process for selection of materials of construction (and the referenced documents). They are grouped into the following categories:

A. General
B. Plant Cooling Water (PCW)
C. Chilled Water (CHW)
D. HVAC
E. Electrical
F. Additional Questions
G. Report of Meeting May 13, 2003
H. Report of Meeting June 13, 2003

The questions and answers are arranged into tables and organized into columns, which are:

Question - The question or line of inquiry raised by ORP.
Comment - Additional information supplied by ORP to clarify the question.
Response - The BNI response to the question.

Appendix B

BNI Responses to ORP Technical Design Oversight Questions LAW Melter Support Systems

A. General

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. What is the status of the design of the support systems, e.g., % complete.		Based on CFD model we know about 90% of what we need for cave cooling. P&IDs for systems: PCW, CHW, PSA, & ISA were issued rev. 0. Remaining is model review 'pick-ups'.
2. Is the current design of the support systems consistent with 2 or 3 LAW melters.	Please provide a document that describes the approach used by BNI in identifying which systems and components would be downsized as a result of the change to 2 LAW melters and those that were not.	Equipment is designed for 2 melters and piping for 3 melters. See contract modification per letter from Roy J. Schepens to RF Naventti.
3. What steps have been taken in the redesign of the support systems to facilitate re-installation and operation of the third melter if this becomes desirable in the long term?		Support equipment can be replaced with larger duty units. Piping can be extended to Melter 3 areas. Also see above.
4. Please provide current system descriptions, PFDs, P&IDs, list of calculations, list of equipment specifications, … for the following systems: PCW, CHW, LRH, LPH, LFH, LEH, C1 through C5 Ventilation Systems…		The redlines of the P&IDs are on stick files w/Law Mechanical Systems. We also have calculations on file.(Shown to Mr. Larry Demick). We will provide additional information as needed.
5. Are the expected times for container handling cited in the LAW Vitrification Capacity and Availability Study still valid? If these have been revised please provide the current estimates of the cycle times for container filling, cooling, inerting, welding, decon., inspection, export and cooling prior to disposal.	24590-LAW-RPT-ENG-01-001, Rev 0	Bounding conditions used by HVAC's CFD program were provided by BNI's Mechanical Handling Group. A copy of the bounding conditions have been provided to DOE.

Appendix B

BNI Responses to
ORP Technical Design Oversight Questions
LAW Melter Support Systems

B. Plant Cooling Water System (PCW)

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. Hold item 4 of 24590-LAW-M6-PCW-00003 indicates that the equipment on that drawing has been purchased. Please provide the vendor data sheets for PCW-HX-00004A/B design.	It appears that the heat exchangers were sized to support three melters. Are these heat exchangers to be installed?	Heat exchangers went out for bid with data sheets that were revised to incorporate changes for increased melter cooling loads. Additional recent changes in the melter cooling requirements have put this item on hold pending re-bid. The heat exchangers will be resized & data sheets will be revised. Heat exchangers for two (2) melters will be installed.
2. Can the HX-00004A/B be run together, i.e., in parallel, if required to increase heat removal from the melters?	24590-LAW-M6-PCW-00003	No. The circulating pump flow cannot be increased for bringing on the second heat exchanger. However, the heat exchanger can have its capacity increased by up to 25% with additional plates being added.
3. Hold 1 on the above P&ID refers to the temperature control system incorporating PCW-EVAP-00001. Is this capability to be retained in the system?		Standby cooling for the melter will be provided in the event of loss of site power by using fire water in a once through flow. The standby chillers will be eliminated.
4. The calculations and the P&ID for the melter power supply cooling water supply assume three melters, i.e., 4 power supplies and 18 electrical buses. Is this design capacity to be retained with the 2 melter configuration?	P&ID 24590-LAW-M6-PCW-00002 Calculation 24590-LAW-MEC-PCW-00001 PVW-HX-00007 A/B The data sheets for the heat exchangers appear to be for a 2 melter configuration. Please confirm.	The equipment will be purchased to support 2 melters. The piping will be sized for 3 melters. The system can be revised for the addition of the 3rd melter. The heat exchanger data sheets were revised for two melters configuration. However, recent design updates warrant the data sheet being revised again and re-bid of the heat exchanger will occur. Auxiliary power supply unit will be eliminated and bus bars will be air cooled. These items will not need water cooling.
5. The calculations for the pour cave cooling panel water supply assume a standard primary to secondary loop heat exchanger configuration (HX-00018A/B or 19A/B [the numbering varies depending on the calculation and the drawing being reviewed.] One of the P&IDs for this system does not include a heat exchanger. The pour cave panels are directly cooled by PCW from BOF. What is the current configuration of this system and what are the current calculations that set the flow rates to the cooling panels?	P&ID 24590-LAW-M6-PCW-00009 (3shts) Calc no. 24590-LAW-MEC-PCW-00012 (committed) P&ID 24590-LAW-M6-PCW-00008	P&ID 24590-LAW-M6-PCW-00008 interfaces with BOF and distributes all the pour caves closed loop cooling water via P&IDs 24590-LAW-M6-PCW-00009, 00010, 00011, 00013, 00014, & 00015. The CFD model calculation sets the cooling loads for the panels and the calculation for the PCW-HX-00019A/B heat exchangers sets the flow rates. P&IDs are being revised to include only 2 melters etc.
6. The calculation for pour cave and transfer tunnel cooling reference CFD analyses being conducted by Bechtel San Francisco. The discussion indicates that the calculations resulted in excessive concrete temperatures and that additional water cooling was	Calc no. 24590-LAW-MEC-PCW-00012 (committed) Please provide references 9.2, 9.3, 9.4, 9.5 and 9.6 of the calculation.	Yes. The latest CFD analysis shows that the concrete temperatures are within the design limits. To protect these concrete areas we have added 6" thick insulation to make sure they stay below the maximum temperature. Insulation sizing was confirmed to be adequate with CFD

Appendix B

BNI Responses to
ORP Technical Design Oversight Questions
LAW Melter Support Systems

B. Plant Cooling Water System (PCW)

ORP Question	Additional ORP Information Concerning the Question	BNI Response
provided to resolve that problem. Are the CFD and the system design calculations complete and consistent?		modeling. The calculations are not final.
7. The calculations for the cooling requirements for the pour caves are based on single line operation but include a factor of 1.33 to account for alternating use of the two lines per melter. This implies that the two lines will not be operating at full capacity. If they were it appears that the heat load would be a larger multiple of the single line (approaching 2). Has the basis for the 1.33 been evaluated for current operating assumptions?	Calc no. 24590-LAW-MEC-PCW-00012 (committed) The calculation states that the 1.33 is based on earlier CFD model results from reference 9.2 of the calculation. It is not known on what operating scenario this factor was based. It is understood that this calculation may no longer be explicitly relevant since these heat exchangers may no longer be used in the system. However, the heat loads should be relevant and have to be accommodated by the pour cave and transfer tunnel panels and the BOF supplied PCW.	The 1.33 factor is the total for both lines for each melter operating at full capacity. The basis is from an earlier CFD analysis that included alternating cave use for each melter. This basis is valid for the current operating assumptions. This criteria was checked to be bounding after the change in glass properties. A sketch showing the carousels and the cooling curve for the canister will be forwarded later. See Attachment B-1 for additional information
8. The pour cave and transfer tunnel calculations assume a 10 hour cooling time. It is believed that these calculations were completed before the canister storage area was removed from the design. It is understood that a significantly longer cooling time may be required before the canisters can be buried. What is the impact of the increased cooling time on the heat load in these areas? Where is this accounted in the calculations?	Calc no. 24590-LAW-MEC-PCW-00012 (committed)	The 10 hour cooling time was prior to the canister being removed from the pour cave. The canister has three stages of 10 hrs fill, 10 hrs cooling, and 8 hrs in the cooling station. There are total of 18 hrs from time it is full till it is discharged from the cave. CFD calculation examines container temperature at 28 to 48 hrs scenarios. CS fan sizing calculation used CFD to derive space temperature.
9. The only calculations for finishing line heat loads that are available on the ORP version of BNI DocSearch are BNFL calculations. Please provide current calculations for these loads.	BNFL Calculation CALC-W375LV-HV00025, Rev 0	Up-to-date calculations have been provided to DOE. See calculation 24590-LAW-MAC-CSV-00001, FAN Sizing. A more comprehensive heat load calculation is forthcoming (to replace 24590-LAW-M8C-CSV-00002).
10. What is the intent in the number of canisters that may be resident in the several stags of the finishing line? For example, will operating restrictions be imposed that permit only one canister to be in the finishing line at one time or is it possible that a canister could be resident at each station of the finishing line?	It appears that there are three locations or stations on the finishing line that could contain a canister, (1) inert and weld, (2) decon, swab and monitor, (3) on transfer bogies between the pour caves, between stations and transfer to the buffer area. The attached figure shows the elapsed time and residence time in each of the locations (based on LAW Vitrification Capacity and Availability Study 24590-LAW-RPT-ENG-01-001, Rev0). The heat load in	The present calculations are based on welding the lids (new trend is for pressing in a castled lid & seal). The calculations of heat load are based on Mechanical Handling Group bounding canister handling (conservative). These times are included in calculation 24590-LAW-MAC-CSV-00001, which has been provided to DOE (page A7-26).

Appendix B

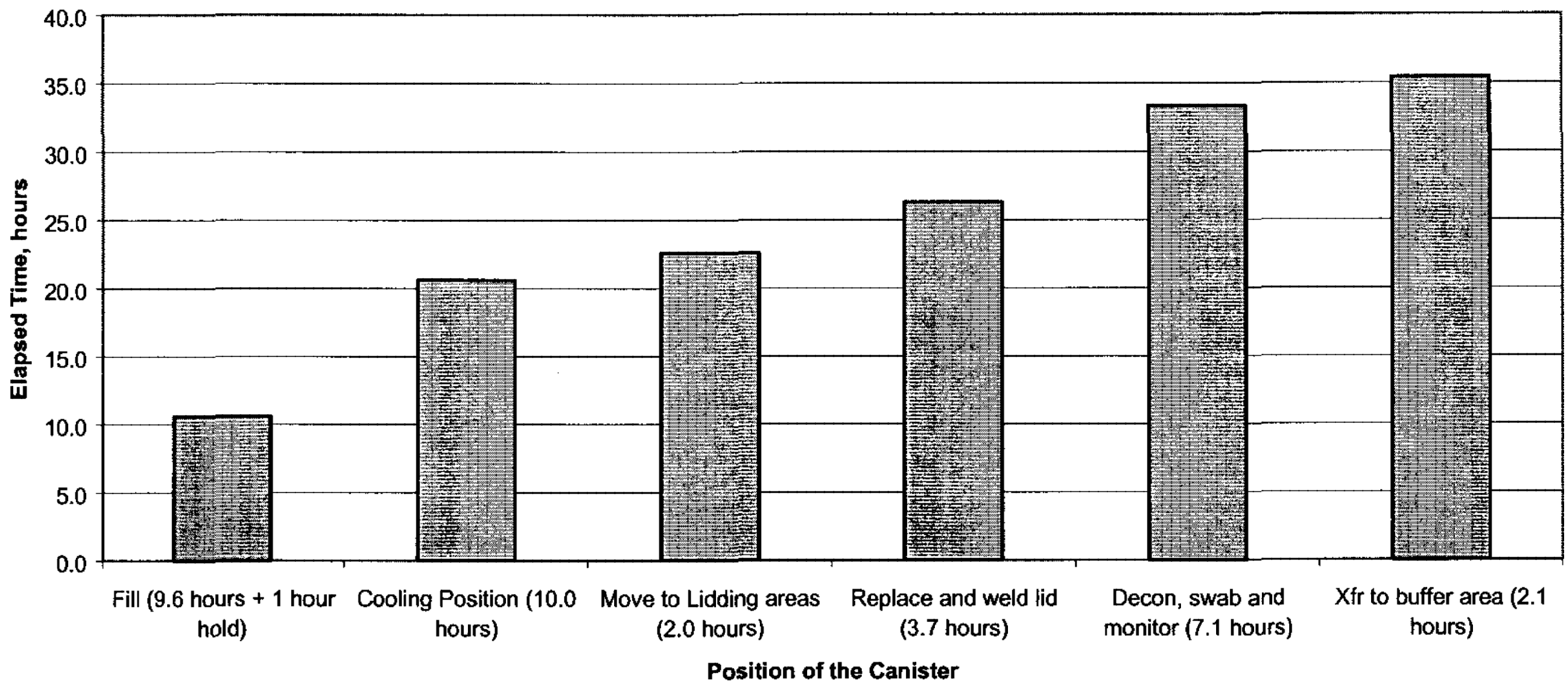
BNI Responses to
ORP Technical Design Oversight Questions
LAW Melter Support Systems

B. Plant Cooling Water System (PCW)

ORP Question	Additional ORP Information Concerning the Question	BNI Response
	each area will depend on whether the line is designed to run continuously where each station could contain a canister at all times (an assembly line approach) or on a batch basis where a canister exits the line before the next enters. The original BNFL calculations assume a canister is resident in each station. However, the number of stations appears to have changed from the original BNFL design.	
11. How are the requirements for cooling water from BOF formally transmitted and kept up-to-date as the design evolves?	Is there a BNI procedure for transmittal of interface requirements like these?	When the service schedule is updated it is sent to BOF for Review. When significant changes are in the offing or a system's calculation is revised, BOF is informed verbally and/or by mail. Also, after Rev. 0 of the P&IDs are issued DCAs track changes.
12. There is no information on PCW-EVAP-00001 on the ORP version of BNI DocSearch. Please provide documents that describe the design capacities for this component and bases for them.		These standby chiller components will be replaced by a more reliable system. The DCA is being started to implement this change. The current design of the chillers meet the full cooling requirements of each melter. This is in response to each melter running at full capacity at the instant of loss of site power. Also, temperature rise limits in the melter cooling loop are considered. The loads to BOF are very conservative. BOF is basing their calculations on 5 cooling towers whereas they have 6 cooling towers, giving even more margin. Evaporator EVAP-00001 will be deleted.

The above is for 2 rooms

Typical ILAW Canister Processing Sequence



see page A7-26 of fan sizing calculation.

Attachment B-1 -- Information supporting response to question B.7.

HEAT LOAD:

LAW Single v Alternating Pour Schedule

Heat load into facility as a whole is the same (assuming same container residence time and pour rate), but it goes to different cooling systems.

Single Pour:

More intense heat in pour cave (bounding for container temperatures and wall temperatures)

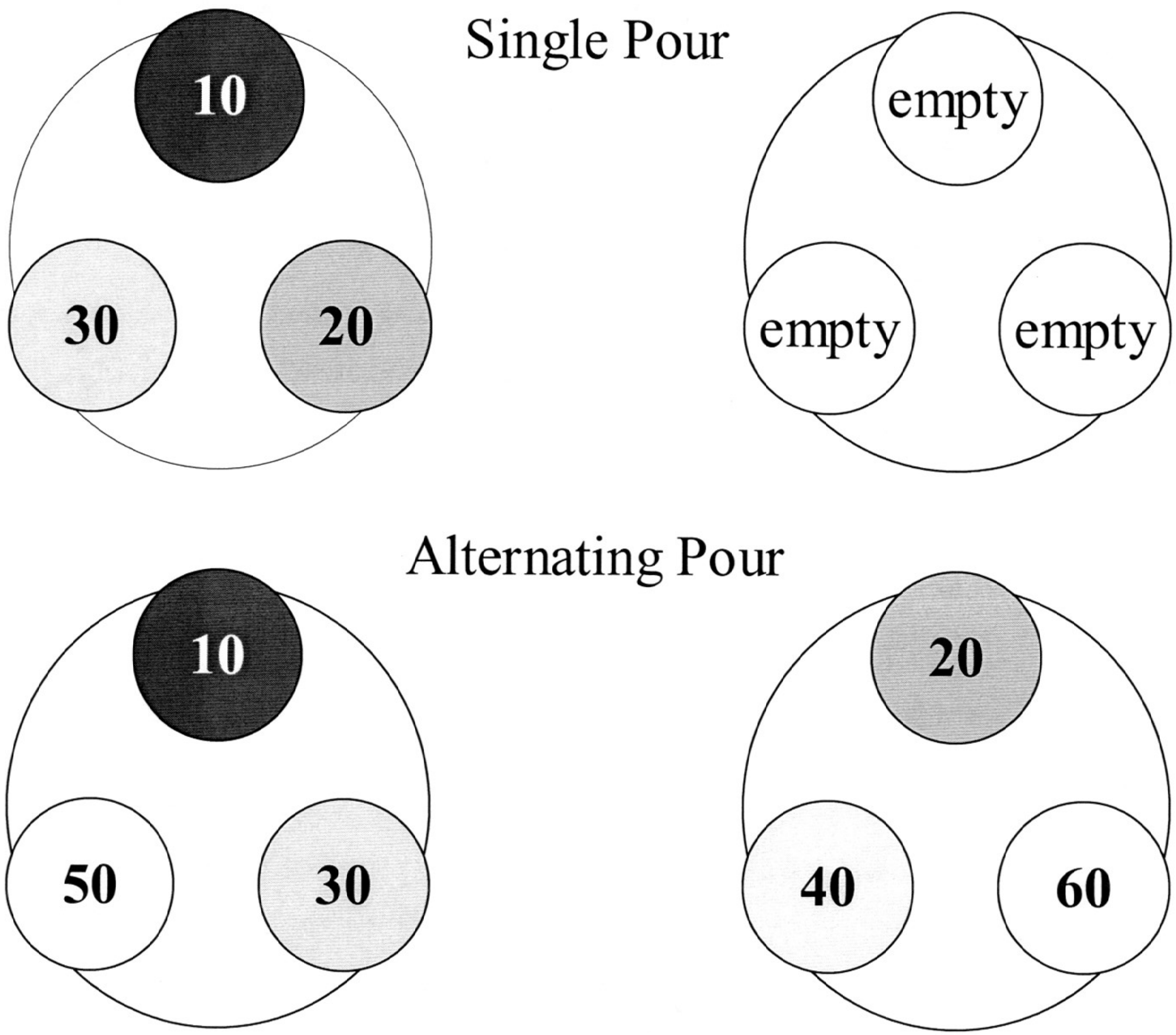
Containers leave pour caves sooner, hotter: bounding for heat load to transfer corridor, buffer storage

Finishing line cannot receive containers directly from single pour (must use Buffer Storage)

Alternating Pour:

More bulk heat load to 4 total pour caves due to more containers resident in caves: bounding for plant cooling water heat load, ventilation leaving air temperature

see next slide



(Numbers on containers indicate residence times from start of pour.)

HEAT LOAD:

Single v Alternating Pour Schedule

Single Pour:

Approximately 265 kW to ventilation and cooling panels (per melter)

10 hr container approx. 150 kW
20 hr container approx. 70 kW
30 hr container approx. 45 kW

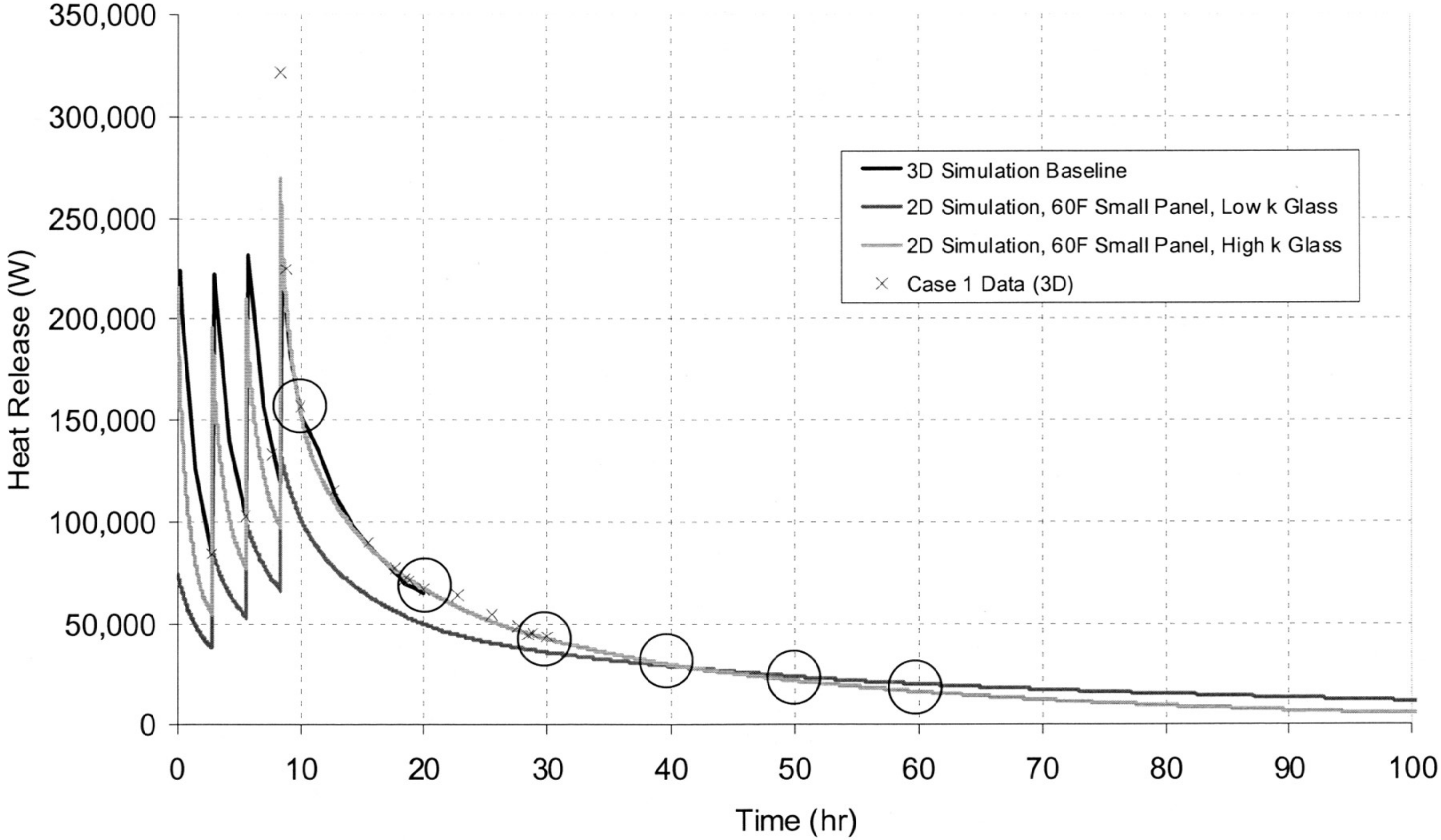
Heat loads are approximate, based upon CFD results shown on next slide.

Alternating Pour:

Approximately 340 kW to ventilation and cooling panels (per melter)

10 hr container approx. 150 kW
20 hr container approx. 70 kW
30 hr container approx. 45 kW
40 hr container approx. 30 kW
50 hr container approx. 25 kW
60 hr container approx. 20 kW

Container heat load varies throughout pour sequence.



Taken from CCN 048236, LAW Container Skin Temperatures

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C. Chilled Water System

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. The Mechanical Data Sheet for the SBS Chilled Water Heat Exchanger cites an heat exchanger duty of 4.215 MBtu/hr. The calculation for this heat exchanger cites a load of 6.322 MBtu/hour. Please confirm that this difference is due to reducing the number of melters supported by this heat exchanger from 3 to 2.	Calc 24590-LAW-MEC-CHW-00002, Rev A MDS 24590-LAW-MED-CHW-00003 Heat exchanger 24590-LAW-ME-CHW-HX-00003A	This is due to the 2+2 melter change. The size was revised for quote only not for purchase. We are in the process of changing from 3 melters to 2 melters.
2. The material balance and process flowsheet assessment indicates that the heat load on these heat exchangers is 5.994 MBtu/hr for the 2 melter case. How is it assured that the specifications for these heat exchangers will be revised to reflect this change in requirements and any others in the future?	24590-WTP-RPT-PT-02-012, Rev 0, Figure 4.7-1	The calculation data for the resized heat exchangers will reference the Process Group's revised calculation for the SBS vessels' cooling, based on the 2+2 melter change. The calculations are tracked in a PDC data base that links them together. The purchase documents are revised also for the 2 melter case.
3. The mechanical data sheet notes require that provision be made for the addition of 25% more plates. Is it practical to increase the number of plates in these heat exchangers after they are placed in service?		Yes. This is a bolted and gasketed design for the Plate and Frame heat exchangers. Revising the performance by adding more plates is one of the advantages of using this type of heat exchanger.

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D. HVAC

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. Please provide documents that describe the current designs of the C1 through C5 systems and the bases for them.		The Basis of Design (draft + exception letter) have been provided to Larry Demick/DOE.

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E. Electrical

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. What is the current estimate of the electrical loading for the LAW plant and specifically for supporting the melter.	The latest calculations available to ORP on BNI DocSearch may not reflect the latest data from Duratek, e.g., the current power requirements for each envelope and the standby power requirements for an idle melter. Calc 24590-LAW-ETC-LMP-00001, Rev A 24590-101-TSA-W000-0010-409-359 Calc –E1C-MVE-00001, Rev B	The current estimate of the melter joule power supply systems is based on the latest data from Duratek. There is a need to increase the power to burn the cold cap when going into idle mode. This increased power requirement coincides w/ the theoretical power requirement for 22 metric tons per day per melter. The purchased power supply will have a margin of about 20% above the maximum requirements and the losses in the transmission.
		LAW electrical power supply capacity is designed to supply a third melter. The 13.8KV feeders from BOF are currently sized to accommodate future melter loads. Current estimate of LAW electrical connected load is approximately 16.2mVA. Note: All MCC's are designed with 10% spare and 15% space per BOD. More information will be forwarded when it becomes available.

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F. Additional Cooling Questions

ORP Question	Additional ORP Information Concerning the Question	BNI Response
1. Attachment 7 of the fan sizing calculation includes finishing line heat loads based on sequence timing summarized in the calculation. With respect to this calculation, (1) an assumption is made that a container arrives every 8 hours. This is not consistent with the current pour times of 10.6 hours and operation on either a continuous or alternating pour schedule. Please confirm that this arrival frequency was selected for conservatism. (2) The airlock arrival times listed under the heading Container Arrival Times for containers 1 through 4 are not consistent with the export residence time listed on the same page. (3.03 hours) The arrival times in the airlock are sooner than would be the case if the correct residence time were used, so the heat load calculation is conservative.	Calculation 24590-LAW-MAC-C5V-00001, Rev D	Fan sizing calculation, section 6.1, lists finishing line temperatures as an unverified assumption. Attachment 7 is provided as additional information. Heat load calculation (to be issued) will formalize these inputs and provide more support for these (conservative) assumptions.
2. Is the finishing line heat load calculation in the fan sizing calculation complete and reflect as close to the final design and timing sequence as possible?	The E-mails attached to this calculation indicate that the finishing line sequence and timing may still be in development.	The heat load calculation (to be issued) based upon the CFD results (to be issued) will contain a more complete analysis of finishing line heat load. There is very little impact on fan sizing from changes in Finishing Line temperature (essentially density through a handful of fittings) because air cascades. A preliminary scoping calculation to determine impact of higher throughput to finishing line temperature determined that throughput be increased in the Finishing Line with temperatures remaining below 113 F. The limiting factor is arrival time. If containers arrive in the Finishing Line prior to 48 hours after pour, the Finishing Line heat load exceeds cooling capacity of the inbleeds and the temperature rises above 113.

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Report of Meeting

Date: May 14, 2003
Date of Meeting: May 13, 2003
Place: ETC-1, M-109
Persons Attending: See attached list
Report Prepared by: Larry Demick, ORP

Subject: ORP Technical Oversight of Melter Support Systems for Cooling and Electrical Supply

Reference: D-03-DESIGN-002, "Design Product Oversight Plan, WTP LAW Facility, Melter Support Systems, May 2003"

Purpose:

The reference documents the purpose, objective, process and schedule for the ORP Technical Oversight of the WTP LAW facility melter support systems. On May 13, 2003 two meetings were held between ORP and BNI personnel to discuss preliminary results of reviews of the design, including bases, for the LAW facility water cooling, HVAC and electrical supply systems in support of this technical oversight. The first meeting covered the water systems and HVAC. The second meeting covered the electrical systems and operation of the melter. Open items, questions and lines of inquiry concerning the ORP oversight were also discussed in these meetings and the status of the design of these systems and emerging issues were explored.

The following summarizes the discussions in these meetings.

Summary of Discussions:

1. The purpose, objectives and process to be followed in conducting this oversight were briefly summarized. These are documented in the reference. It was noted that Mr. Isern (the designated BNI point of contact for this oversight) was still working with a draft plan. The final plan was transmitted to Mr. Isern later in the day.

2. A copy of a table summarizing specific questions concerning the design and specification of components for the water cooling, HVAC and electrical systems in the LAW Vitrification facility was provided for meeting attendees and was later transmitted to Mr. Isern by E-mail. These questions were not reviewed explicitly in this meeting, but many of the areas covered by the questions were discussed. Mr. Isern was requested to provide responses to the questions by May 23 or earlier.

3. The modifications of the water cooling, HVAC and electrical systems to accommodate the removal of the third LAW melter comply with the guidance provided by ORP in the January 22, 2003 letter 03-AMWTP-001 from R. J. Schepens to R. F. Naventi, "Modifications to the LOW Activity Waste (LAW) Facility Implementation of the 2+2 Melter Trends". In the context of these systems the principal embedments, piping, tubing, penetrations, transformers, bus ducts, main control centers and UPS are sized to support three melters. The melter specific equipment, e.g., pour cave cooling heat

exchangers, melter power supply heat exchangers, melter power supplies, are sized for two melters. It is noted that the design of the ventilation systems are driven principally by the volume of the facility and the rate of glass production. The latter reflecting the significant heat loads in the pour caves and finishing lines. These two factors are not changed by the reduction to two melters. As described in further discussion below there have been other changes that have had significant impact on the design requirements for the ventilation system and the water cooling systems. BNI indicates that the addition of a third melter would require significant redesign of the ventilation systems.

4. Some of the more significant heat loads on the water cooling systems and HVAC systems that support LAW facility operation are those in the melter pour caves and in the finishing line. The heat emitted from the LAW canister as it is being filled and as it cools while residing in the pour cave and transiting the transfer tunnels and the finishing line is the source of these loads. The design heat loads in the several locations in the pour caves, transfer tunnels and finishing lines exposed to the filled canisters are based on the results of Computational Fluid Dynamic (CFD) models and analyses performed for the WTP project by Bechtel, San Francisco. The amount of heat generated by a filled container, and the rate at which that heat is transferred to the environment, depends on several factors including the heat capacity and thermal conductivity of the glass. These are parameters that have significant impact on the results of the CFD analyses. In July 2002 (see CCN 036415) the estimates for these glass parameters were increased significantly and characterized as a function of glass temperature. This resulted in significant increases in the heat loads in these areas requiring increases in the capacity of the water cooling and HVAC systems supporting these areas.

   Following the meeting BNI provided ORP with a draft report on the latest analysis of the heat load in the LAW pour caves and finishing line (24590-LAW-M4C-C5V-00001, Rev A (Draft)). This report provides bases for sizing of the pour cave cooling panel system and ventilation system for pour cave and finishing line cooling.

5. The amount of time that the filled container spends at each station during pouring, cooling and finishing also affects the facility cooling requirements. It was stated that the current sequence calls for the canister to be in the pour cave for a total of 28 hours from the start of pouring to export (10 hours pour position, 10 hours cooling position and 8 hours in the import/export position). During Normal operations, containers spend 48 hours in the pour cave. Containers with only 28 hours of pour cave time must be cooled for an additional 20 hours in the transfer tunnel or Buffer Storage area before removal to the Finishing Lines. Containers with 48 hours of pour cave time can be transported directly to the Finishing Lines.The canister will be in the finishing line for an additional 12 hours for a total elapsed time of 60 hours from initiation of pour to export from the facility and transfer to the DOE disposal site. This establishes the temperature and heat loss rate for the canisters at each station of the finishing line and the final skin temperature and heat contained in the canister when it is shipped to DOE. Temperature can vary greatly depending on environment.

   It is understood that 48 hours cooling time is required to achieve a canister temperature consistent with that required to enter the inerting/sampling/lidding position. This is due to finishing line cooling capacity.

   The baseline scenario and the likelihood of changes to the sequencing and timing of the finishing line will be discussed with the material handling group in a separate meeting. The increase in heat loads due to the change in glass properties had a major impact on the design of the pour cave water cooling system.

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6. The increased loads required an increase in the number of cooling panels in the pour cave, strategically locating the new panels in critical areas and resulted in changing the heat sink to the plant cooling water system (system PCW) originally designed to be served from the chilled water system (CHW).

   The interface with the BOF plant cooling water system is at the pour cave cooling panel heat exchangers (PCW-HX-00019A/B). The cooling panels are supplied with demineralized water in a closed loop system using these heat exchangers as the heat sink in that loop. These are plate and frame heat exchangers and specified with typically 15% margin on heat load. The specification, however, for the heat exchangers requires that provision be made for addition of 25% to 50% more plates. According to BNI, the addition of plates to a heat exchanger that has been in service is straightforward. Additionally, the piping for the cooling water supply from BOF was sized to accommodate three melters at a nameplate rating of 15 MTG/day each so additional cooling water could be provided in the future, if required.

   7. It is noted (by the writer) that maintaining pour cave air and building structure temperatures within design limits is accomplished though a combination of ventilation and strategically placed cooling panels and also insulation to protect structural members in the event that the water cooling is lost (6" to 9" thick microporous silica on all pour cave surfaces. The maximum heat load on an individual panel depends on its location. Each panel is designed for the maximum load and the heat exchangers are designed for the combination of these loads. However, the panels are not necessarily all exposed to the maximum heat load simultaneously. During the pouring, cooling and export sequence within an individual pour cave the cooling panels will be exposed to their maximum heat loads at different times in the sequence. Therefore, there is, inherent margin in the capacity of the pour cave cooling heat exchanger design. It is noted, however, that the critical requirement of this system is to limit pour cave structural temperatures below maximum operating limits. This depends on the capability of each panel at its maximum load.

7. The layout of the cooling panels was reviewed briefly. It appears (to the writer) that the majority of the pour cave surfaces are covered by cooling panels and that there is little space available to add panels to increase the cooling capacity in that area. It was pointed out by BNI that an increased heat load in the area, (e.g., if the melters were operated at higher throughput than the current baseline such as 22 MTG/day versus 15 MTG/day) would be an increase in the cooling water differential temperatures and a small increase in the structural and air temperatures which BNI personnel consider would be within the capabilities of the SSC specifications.

8. As a result of a recent trend the backup requirements for the melter cooling panels and power supply systems have been removed. This resulted in the removal of the evaporators and associated backup supplies in these systems. Backup cooling to the melters will be supplied from fire water. Whether the backup system will be manually or automatically engaged is still under consideration. P&IDs have been red-lined and calculations and specifications are being revised to reflect this change.

9. The number of heat exchangers and closed loop systems for melter cooling has been reduced to two. The capacities of the melter power supply cooling heat exchangers have been reduced to cover the two remaining melter power supplies.

10. BNI provided a hard copy of the calculation for sizing of the LAW C5 Exhaust fan (24590-LAW-MAC-C5V-00001, Rev D). This calculation reflects the results of the latest pour cave and finishing line CFD analyses (referenced above) which consider the current "bounding" glass properties and the

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two LAW melter configuration. The reduction in the number of melters permitted redirecting ventilation flow from the 5th and 6th caves to the other four maintaining overall flow requirements similar to the last analyses. The current flow requirements did increase the required fan motor size from 250 to 400 horsepower.

It is understood that without significant redesign or innovation (e.g., locating fan units in the pour caves for the third melter) that there is no space available in the facility for additional fan units, including the fans, motors, coolers and filters.

11. The principal loads on the chilled water system (LAW-CHW) are the cooling coils in the off-gas system submerged bed scrubbers, the fan coil units and the ~90 local HVAC units. These are supplied directly from the BOF chilled water system. The calculations of return temperatures from the fan coil units have been affected by the changes in the CFD analyses discussed above. The overall loads in the building and local HVAC units have been affected by the changes in the CFD analyses (e.g., in the finishing line) and the elimination of the third melter. It is assumed that the standard BNI design criteria safety factors characterize margins in these system designs.

    It is also noted that the supply lines at the interface with BOF are sized for more flow than currently required. This is not considered at this point to be a limiting factor for this system. The installed heat exchange area is considered the limiting factor for this system.

    The design of the Submerged Scrubbers and requirements on CHW will be reviewed as part of the review of the off-gas systems which will be discussed with BNI in another meeting.

12. During the discussion it was noted that the BNI design criteria include a safety factor of 15% on heating and cooling loads and 20% for system static pressure loss. This was verified (by the writer) in review of 24590-LAW-M0C-G40T-00001, Rev1, "HVAC Heating and Cooling Load Calculations General Design Criteria". It was also stated that pump design adds a 10% or 10 psi (whichever is larger) margin on total developed head. This has also been verified (by the writer) in prior review of pump sizing calculations. The flow margins identified in these reviews (by the writer) vary depending on the application and vary from a few percent to 10% of the nominal required flow. These safety factors would be in addition to other conservatisms or margins discussed in this meeting. CS lines have reserves of 20% on static pressure and 10% flow.

    With respect to overall margin of the cooling and HVAC systems it appears that the largest factor is the assumption on glass heat capacity and thermal conductivity in the CFD analyses. This is emphasized in the CFD analysis report, Assumptions Section 6.1, Glass Properties*, "… The glass properties … are based on assumptions rather than measured data. These assumptions require verification." It is understood that glass pours to be initiated in the pilot melter August 2003 will provide more definitive data on these glass properties. The margin or conservatism of the cooling and HVAC systems will depend on how the values used in the CFD analyses compare with the measured properties.

    (For the purposes of the current ORP technical oversight, it will be assumed that the glass properties used in the CFD analyses are appropriate. Several other vitrification processes were studied to determine "bounding" properties. Because glass chemical consistencies varied from DWPV and West Valley glasses, modeling was used to calculate thermal properties of the mixture based on known thermal properties of the constituents of LAW glass. Margins in the cooling and HVAC systems will be based on the BNI design criteria unless other more definitive factors are identified.)

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13. The electrical systems supporting the melter, principally the electrode power, are designed to accommodate the maximum load at 80% of the design capacity of the equipment. The maximum load is based on the latest Duratek design calculations and occurs during the transient between operating and idling conditions. The design calculations reviewed earlier by the writer indicate that the electrode power supplies are sized for a melter throughput of 22 MTG/day. This was confirmed in this meeting.

    The auxiliary electrode power supply has been eliminated from the power system design since the current power supplies include an auxiliary provision. Two power supplies are included in the current design.

14. Prior reviews of load calculations and design data sheets for the LAW facility by the writer identified significant margin in the installed capacities of the electrical components. For the major components, e.g., supply switchgear, bus ducts, this is consistent with the ORP guidance document referenced above. In most cases the specific electrical loads have bee reduced as a result of the elimination of the third melter, e.g., pump motors are smaller, and local MCCs are not installed. These could be increased and additional equipment installed at a future date if needed to support an increase in the LAW facility production rate. The main electrical power supplies are capable of supporting the facility to a 45 MTG/day production rate with a 20% margin (The maximum load is approx. 80% of the installed load).

15. The capabilities of the BOF systems that supply the LAW facility were not discussed explicitly in this meeting but the BNI personnel believe they have sufficient capacity to support an increase if needed in PCW or CHW flow. This will be confirmed in review of interface agreements and design documentation for the BOF.

16. It was noted during the discussions that the performance of the pilot melter has varied considerably depending on the feed composition. Production rates from 1.3 MTG/m^2/day to 2.5 MTG/m^2/day have been required to maintain proper melter plenum and glass pool temperatures. It is possible that the LAW facility may experience this range of variation in melter performance. If the increased rates can not be handled by the LAW support systems the melter may have to be idled. It was noted that operating the melter with the high plenum temperatures that occur in the idle condition (or with high plenum temperatures in general) will reduce the life of the melter. Means other than varying feed rate for controlling plenum temperatures are being explored.

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Attachment

List of Attendees:

BNI:

John Thomas	HVAC Supervisor LAW	371-5871
Elaine Diaz	HVAC Lead LAW	371-5869
Eric Isern	Mechanical Systems LAW Supervisor	371-5799
Rich Tometczak	Mechanical Systems :LAW Lead	371-5798
Sid Sourani	Mechanical System LAW Lead	371-5802
Scott Goad	Electrical Melters	371-2776

WGI:

Loyd Donovan	Melter Systems Supervisor	371-5830

ORP:

Peter Furlong	LAW Facility Project Manager	371-5744
Larry Demick	ORP Engineering Support (Consultant)	372-3249

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Meeting Minutes

CCN:	**Error! Unknown document property name.**
Group Chair/ Secretary:	*Eric Isern*
Meeting:	*Date / Time 6-13-03/ 9:00 AM to 11 AM*
	Location ETC-1 LOBBY
Next Meeting:	*Date / Time 1:00 to 3:00 PM (tentative)*
	Location P-228
Purpose:	ORP Technical Oversight of LAW Melter Support Systems
Prepared by:	Sid Sourani

PURPOSE: The different design margins & bottlenecks that limit the capacities of the LAW capacity were looked at. The LAW melters capacities were not part of this analysis. Seven areas were looked at, but only four are of main interest: Mechanical Handling, Hvac, Electrical, & Utilities.

The intent is to compare the capacity in the equipment specification to the basis of design in order to arrive at the design margin available. The contract calls for 733 units of sodium/year.

SUMMARY OF DISCUSSIONS: Listed in order of greatest current capacity limitation to throughput.

1. **Mechanical Handling:** The two limiting areas in Mechanical Handling are:

- Export Bay: requires 4 1/2 hours per canister which translates to approx. 5 1/2 canisters per day, or 32 MT/D for two melters.

- Lidding (Welding) Station: Current capacity 48 MT/D capacity.

There is a concern that if there is only one crane and one truck, and a failure of either will impact throughput.

2. **Melter Feed:** Glass former supply is rated at 33 1/2 MT/D. Dumping time from hopper into the feed prep vessel should not be more than 1/2 an hour with 3 1/2 hours for blending. Melter feed preparation and blending can produce much more by manipulating the batch time. The 11 hours required for testing (for 4 batches) was a constraint from the lab group and is not limiting. The pumps for transferring feed from the Feed Preparation Vessel (MPV) to the Melter Feed Vessel had a capacity of 88 GPM but they are now resized for 50 GPM, however this slower transfer time is not limiting. There are 6 ADS pumps feeding the melter. Three ADS pumps have the capacity to feed the melter at 100% capacity. The ADS pumps are air driven reciprocating, and probably can be speeded up. Duratek indicated a limitation of 480 GPH & 1.5 GPM per ADS pump.

A parametric analysis was performed assuming a 20% solids feed to the melter and the sampling limitations.

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3. **Ventilation:** According to the CFD analysis canister is produced every 10 hours. The most limiting factor is the cooling capacity at residence time of 28 hours.The most limiting temperature is that of the canister flange. The 28 hours probably was based on single pour and not an alternating pour, based on one bounding case. If we want to minimize carousel moves using the factor of 4 in alternating pour approx. 6 hours per canister is required. This is consistent with Lidding operation which has a limitation of 5 1/2 hours per canister. This means with an additional 3 hours in buffer zone (which may not be acceptable), a 38.4 MT/D can be achieved.

By the end of this summer, the glass properties will be tested by a laboratory, and more precise data is expected. More definitive information from the full scale glass pour is expected. R&T is doing a closer evaluation of the poured glass, actual density, bringing into an account the presence of bubbles. The temperature for CHG to pick up the canister is based on 63 hours cooling time.

Every 6 hours could be a significant heat load increase. Further modeling would be required to examine impact to pour cave cooling system.

Finishing line cooling: 36 MT/D (arrival time limited) analysis shows the finishing line cooling can support 8 containers per day, arriving 48 hours after start of pour.

Question: Can buffer storage area cooling handle extra heat load of all containers arriving after just 25 hours in the pour caves (one every 3 hours)?

Answer: Yes- just Buffer Storage Area Cooling Capacity is 77 tons, which correlates to only 5 containers arriving at this rate: 3 in the Buffer Storage Area and 2 in the rework area. However, new finishing line calculations show containers could arrive in the finishing line at 35 hours from pour start keeping Buffer Storage container content below 5.

4. **Off Gas:** If we double the glass capacity, the ability of the system to handle a surge will go from 7x to 3x and about 5x for 150% capacity. The NOx and CO will increase in the same proportion as the feed. As far as the heat of reaction of NOx with ammonia in the scrubber, we a 50% reserve is expected. A modification of the SBS using a heat exchanger may be adapted for anticipated higher temperature. The SCR margin is not known, but it may handle the increase.

5. **Electrical Power:** At the present melter design the power supply (joule heating), is able to handle 22 MT/D per Melter. The heat exchangers to the melter can have 50% capacity increase. The water circulating capacity has an additional 25 to 35 % reserve capacity. This provides plenty of margin. Duratek can decrease the refractory thickness thus increasing the effective melter surface area. Duratek can also increase the glass temperature by about 50 degrees Centigrade. These two factors will increase the melter capacity, but will also increase the melter cooling requirements.

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Use as applicable

Action Table

Action Item	Responsibility	Due Date	Action to Close

Signature

Distribution (Attendees have an asterisk following their name)	MS11-B
PDC	
John Orchard *	DOE
Larry Demick *	DOE
Russ Treat *	DOE
Eric Isern *	MS6-R1
Elaine Diaz *	MS6-M2
Paul Latham *	MS6-R2
Jan Mazurak *	MS6-P2
Sid Sourani *	MS6-R1
	MSIN

E-STARS™ Report
Task Detail Report
08/01/2003 12:26

TASK INFORMATION			
Task#	ORP-WEC-2003-0035		
Subject	Concur: 03-WEC-036 Design Oversight Report _ "LAW Melter Support System Capacities," Ð 03-Design-002		
Parent Task#		**Status**	Open
Reference	03-WEC-036	**Due**	
Originator	Weisenberger, Donna J	**Priority**	None
Originator Phone	(509) 373-1203	**Category**	None
Origination Date	07/31/2003 14:11	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	bcc: WEC OFF FILE WEC RDG FILE AMWTP RDG FILE J. R. Eschenberg, AMWTP W. F. Hamel, WEC J. E. Orchard, WEC Correspondence is being routed by hard copy, please approve, initial and date and return to Donna Weisenberger.		

ROUTING LISTS		
1	Route List	Active
	• Orchard, John E - Approve - Approved - 08/01/2003 12:23	
	• Hamel, William F - Approve - Approved with comments - 08/01/2003 12:24	

ATTACHMENTS

No Attachments

COMMENTS	
Poster	Hamel, William F (Weisenberger, Donna J)- 08/01/2003 12:08
	Approve
	Donna Weisenberger electronically concurred for Bill Hamel.

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

RECEIVED
AUG 0 4 2003
DOE-ORP/ORPCC

E-STARS™ Report
Task Detail Report
07/31/2003 02:20

TASK INFORMATION			
Task#	ORP-WEC-2003-0035		
Subject	Concur: 03-WEC-036 Design Oversight Report _ "LAW Melter Support System Capacities," D-03-Design-002		
Parent Task#		**Status**	Open
Reference	03-WEC-036	**Due**	
Originator	Weisenberger, Donna J	**Priority**	None
Originator Phone	(509) 373-1203	**Category**	None
Origination Date	07/31/2003 14:11	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	bcc: WEC OFF FILE WEC RDG FILE AMWTP RDG FILE J. R. Eschenberg, AMWTP W. F. Hamel, WEC J. E. Orchard, WEC Correspondence is being routed by hard copy, please approve, initial and date and return to Donna Weisenberger.		

ROUTING LISTS

1	Route List	Active
	• Orchard, John E - Approve - Awaiting Response	
	• Hamel, William F - Approve - Awaiting Response	

8/1/03

ATTACHMENTS

No Attachments

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

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