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

SEP 0 9 2004

04-WED-052

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

Dear Mr. Henschel:

CONTRACT NO. DE-AC27-01RV14136 – SUBMITTAL OF THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT ON PRETREATMENT FACILITY EVAPORATORS

This letter transmits the Pretreatment Facility Evaporators Design Oversight Review Report (Attachment), that documents the conclusions, recommendations, and open item that were identified during the conduct of this oversight review. The objectives of this oversight were to identify the design requirements for the Pretreatment Facility evaporators, confirm that the technical bases were definitive and supported by analysis, and verify lessons learned from other evaporator systems were being utilized for the design of these evaporators.

One open item and four recommendations were identified requiring Bechtel National, Inc. (BNI) responses. In addition, two recommendations were identified for ORP. BNI shall address the open item and recommendations as soon as practicable and is encouraged to work with ORP personnel to satisfactorily address the issues.

ORP appreciates the support received from BNI staff in the performance of this review. In particular, the efforts of Jerry Chiaramonte, John Hall, and Elvis Le were critical to the completion of the design review. ORP encourages further cooperation in the closure of the open item and recommendations identified in the report. Please provide ORP with a written response to the open item and recommendations contained within this report. The open item and recommendations shall be entered into the BNI Recommendation and Issue Tracking System.

If you have any questions, please contact me, or your staff may contact William Hamel, Waste Treatment Plant Engineering Division, (509) 373-1569.

Sincerely,

Robert C. Barr for

Roy J. Schepens
Manager

WED:TAS

Attachment

cc: See page 2

cc w/attach:
G. Chiaramonte, BNI
G. Duncan, BNI
R. Tosetti, BNI

ATTACHMENT
04-WED-052

DESIGN OVERSIGHT REPORT

REVIEW OF BNI DESIGN FOR PRETREATMENT FACILITY EVAPORATORS

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

DESIGN OVERSIGHT REPORT

REVIEW OF BNI DESIGN FOR PRETREATMENT FACILITY EVAPORATORS

September 2004

Design Oversight: D-04-DESIGN-004

Team Lead: Todd Shrader

Reviewers: Brian Harkins

Greg Gibbs

Concurrence: William F. Hamel, Director
Waste Treatment and Immobilization
Plant Project Engineering Division

Approved: John R. Eschenberg, Manager
WTP Project Office

EXECUTIVE SUMMARY

A primary mission of the US Department of Energy (DOE), Office of River Protection (ORP) is the construction of the Waste Treatment and Immobilization Plant (WTP) in the 200 East Area of the Hanford Site. As part of its oversight responsibilities, the WTP Engineering Division (WED) of ORP performed a design oversight review of the Pretreatment Facility evaporator systems in May 2004. Three personnel from ORP and its support contractor were designated to perform the WED design oversight review. The purpose of the design review was to ensure applicable contract and design criteria were being met by the evaporator designs and that the evaporators would meet mission needs for the WTP. Vertical slices of various aspects of the design criteria and activities were reviewed to verify acceptability.

Within the Pretreatment Facility, there are four evaporator systems. Each evaporator system consists of a reboiler, a separator, a condenser, a condensate vessel, various pumps, vacuum systems, air injectors, steam conditioners, and an anti-foaming supply system. To protect workers from radiation exposure, components that are in direct contact with the waste are located in either the black cells (separators) or the hot cell (reboilers). The Waste Feed Evaporation Process (FEP) system has two identical evaporator systems. The Treated Low Activity Waste Evaporation Process Feed (TLP) system has one evaporator system. The fourth evaporator system is part of the Cesium Nitric Acid Recovery Process (CNP) system. The FEP and TLP evaporator systems were at the 60% design stage. The CNP system was at the 30% design stage. All four evaporator systems (FEP A, FEP B, TLP, and CNP) were very similar in design with the only substantial design differences in the sizing of components.

The following were the specific objectives of this design oversight:

1. Identify and understand the Bechtel National, Inc. (BNI) design requirements for the Pretreatment Facility evaporators;

2. Understand the technical bases for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing, or experience; and

3. Verify lessons learned from the operation of other evaporators across the DOE complex have been incorporated into the design process.

This design oversight included a review of elements of the Pretreatment Facility evaporator design criteria, requirements, drawings, specifications, contractor design reviews, specifications, and other similar design documentation. The FEP and TLP evaporators were the focus of the review due to the maturity of design.

The oversight was conducted within the guidelines of ORP PD 220.1-12, 2/12/03, "Conduct of Design Oversight." Evaluated information was collected from various BNI documents, DOE documents, interviews with BNI design staff, and a tour of the 242-A Evaporator with associated discussions with CH2M HILL Hanford Group, Inc. (CH2M HILL) staff.

Seven specific areas were identified for review. Review of these areas was determined to provide the information required to meet the design review objectives.

- Lessons learned from the 242-A Evaporator
- Safety basis compliance
- Operability of the systems
- Applicability of radiation monitoring equipment
- System functionality for various solids concentration ranges
- Design life of black cell components
- Remotability of hot cell components

The methodology of review depended on the area. The lessons learned review was performed mostly with interviews with BNI and CH2M HILL staff. The operability of systems review was performed through BNI staff interviews and documentation review. The safety basis compliance and systems functionality reviews were performed through the review of system descriptions and research and technology reports along with interviews with various BNI staff. The black cell and hot cell component reviews were performed through a review of requirements documents, previous DOE assessments, engineering specifications, and BNI staff interviews. The review of the radiation monitoring equipment was discontinued after it was determined the design of the equipment was in the preliminary stage and insufficient documentation existed to perform a review. Due to limitations on the review team's time and resources, representative reviews were performed and in-depth reviews of every component were not performed.

Emphasis for the review was placed on application of contract and requirements documents to the design, application of lessons learned, and operability of the design. Vertical slices of design elements or requirements were reviewed in order to gage the overall effectiveness of the design process for the Pretreatment Facility evaporators. The following seven lines of inquiry (LOI) were pursued:

LOI-1: Are the safety requirements identified in the Preliminary Safety Analysis Report (PSAR) for the FEP Evaporators correctly translated into the design documentation?

LOI-2: Have the results of the Research and Technology tests reports required any changes to the design or operating strategies for the evaporators and are these being adequately pursued?

LOI-3: Have the contract requirements for waste treatment capacity been appropriately implemented for the FEP and TLP evaporator system?

LOI-4: How are lessons learned from other evaporator systems around the DOE complex (such as 242-A) incorporated into the design?

LOI-5: Has an operational strategy been developed and incorporated into the design of the evaporators?

LOI-6: Have the black cell design requirements been included in the evaporator designs?

LOI-7: Have the hot cell components been adequately designed?

It was the conclusion of the design oversight review team that the design process path being utilized by BNI for the evaporator systems was being appropriately implemented and contractual and other requirements being met. Lessons learned from other evaporator systems are being incorporated into the design. Communication between BNI and the evaporator system subcontractor is strong and changes to the design are thoroughly reviewed by all parties. In addition, the evaporator design and fabrication efforts appear to be on schedule and will support the Pretreatment Facility construction schedule.

Two areas of concern were the incorporation of research and technology test data into the component design and the incorporation of the dimensional record program into the design process. The data from the research and technology efforts needs to be fully evaluated in the design process. As for the dimensional record program, BNI has indicated that it is key to the remote operability of equipment in the hot cell, particularly the replacement of equipment. A BNI policy on implementation for existing procurements, such as the evaporator systems, needs to be developed to fully appreciate the benefits of the program.

One open item, four BNI recommendations, and two DOE recommendations have been developed to address these areas of concern. The open item (OI-1) and BNI recommendations (R-1 to R-4) shall be addressed by BNI and should be resolved as soon as practicable. The DOE recommendations (DOE-1, DOE-2) will be addressed by ORP. The DOE recommendations will be resolved as soon as practicable, but after further maturing of the design.

OI-1: Submit a PSAR change to PSAR Section 3.4.1.8.3.1 (and other sections as appropriate) to address the final mitigation strategy for an episodic release of hydrogen in the FEP system. [LOI-1]

R-1: BNI should confirm that the WTP throughput capacity is still preserved with the imposition of the 8.9 Wt% solids limit established for the FEP evaporator separator vessel and recirculation loop. This may be confirmed during production of the next ORP flowsheet assessment deliverables using the steady state flowsheet. [LOI-3]

R-2: BNI should review the results of new hydrogen calculations being prepared for other vessels throughout the WTP to determine any potential model impacts with respect to WTP throughput capacity. This may be performed as part of the hydrogen mitigation/pulse jet mixers trend implementation scope. [LOI-3]

R-3: The results of any model revisions should be reconciled with engineering mass balances. Reconciliation of model revisions with engineering mass balances is routinely performed when the flowsheet assessment deliverables are generated. If it is determined that there are situations requiring any new alternative operational strategies, these shall be developed during the commission phase of the project. [LOI-3]

R-4: A design and procurement strategy should be developed for the implementation of the dimensional record program including for procurements for which specifications have already been issued. [LOI-7]

DOE-1: Upon approval of ABAR 24590-WTP-SE-ENS-04-008, Revision 0, and the issuance of the Software Functional Specifications, ORP should confirm that the safety interlocks identified in the PSAR for the FEP evaporators are correctly translated into the design documentation. [LOI-1]

DOE-2: Upon confirmation of the TLP pumps functional capability based on bounding solids concentration levels provided in the research and technology reports, DOE will confirm the acceptability of the design. [LOI-2]

Finally, the cost to perform this review was tracked. It was estimated to require 75 hours for BNI to support the review and 200 hours for ORP to prepare for and perform the review and to prepare the final report. The estimated cost was $19,000.

INTRODUCTION

A primary mission of the US Department of Energy (DOE), Office of River Protection (ORP) is the construction of the Waste Treatment and Immobilization Plant (WTP) in the 200 East Area of the Hanford Site. The design and construction contractor for the WTP is Bechtel National, Inc. (BNI). As part of its oversight responsibilities, ORP performs various assessments of BNI activities during the design and construction phase. One such oversight is the design review of various facility components and systems performed by the ORP Waste Treatment and Immobilization Plant Engineering Division (WED). Due to the importance to the WTP mission, WED selected the evaporator systems within the Pretreatment Facility (PT) Facility for a design review.

Three personnel from ORP and its support contractors were designated to perform the WED design review of the evaporator systems. The formal design review occurred from May 17 to May 20 and consisted of BNI staff interviews, document reviews, and fact finding. The purpose of the design review was to ensure applicable contract and design criteria were being met by the evaporator designs and that the evaporators would meet mission needs for the WTP. Vertical slices of various aspects of the design criteria and activities were reviewed to verify acceptability. Based on the review, one open item was identified and four BNI recommendations and two ORP recommendations were developed.

BACKGROUND

The WTP complex consists of various facilities to analyze, treat, process, immobilize, and package waste from the Hanford Tank Farms. The three key facilities of the WTP are the Pretreatment Facility, the Low Activity Waste Vitrification (LAW) Facility, and the High Level Waste Vitrification (HLW) Facility. The Pretreatment Facility is designed to receive liquid waste slurry from the Tank Farms and to treat the waste using solid-liquid filtration, ion-exchange, and concentration and blending processes in order to prepare the waste for immobilization at the LAW and HLW Facilities. Because of the highly radioactive nature of the waste slurry, much of the processing in the Pretreatment Facility occurs in either inaccessible black cells or a remotely accessible hot cell. The four evaporators are located in the hot cell, with supporting equipment and components in black cells and other controlled areas of the Pretreatment Facility.

Each evaporator system consists of a reboiler, a separator, a condenser, a condensate vessel, various pumps, vacuum systems, air injectors, steam conditioners, and an anti-foaming supply system. To protect workers from radiation exposure, components that are in direct contact with the waste are located in either the black cells (separators) or the hot cell (reboilers). Components such as the condensate collection vessel are located in the south corridor. The Waste Feed Evaporation Process (FEP) system has two identical evaporator systems. The Treated Low Activity Waste Evaporation Process Feed (TLP) system has one evaporator system. The fourth evaporator system is part of the Cesium Nitric Acid Recovery Process (CNP) system. The FEP and TLP evaporator systems were at the 60% design stage. The CNP system was at the 30%

design stage. All four evaporator systems (FEP A, FEP B, TLP, and CNP) were very similar in design with the only substantial design differences in the sizing of components.

OBJECTIVES

The following were the specific objectives of this design oversight:

1. Identify and understand the BNI design requirements (Contractual and source document) for the Pretreatment Facility evaporators. The review focused on the FEP and TLP evaporator systems as these were furthest along in the design process.

2. Understand the technical bases for these requirements and confirm that the technical bases are definitive and supported by substantive analysis, testing, or experience.

3. Verify lessons learned from the operation of other evaporators across the DOE complex (242-A for example) have been incorporated into the design process.

The design oversight was conducted as part of ORP's responsibility as owner of the WTP to ensure that the design and planned operations comply with the appropriate functional and operating requirements.

SCOPE

This design oversight included a review of elements of the Pretreatment Facility evaporator design criteria, requirements, drawings, specifications, contractor design reviews, specifications, and other similar design documentation. The FEP and TLP evaporators were the focus of the review due to the maturity of design.

The design review was scoped to avoid duplication with other design reviews either recently performed by ORP or planned in the near future. If a previous review had made a recommendation, this review did not duplicate the recommendation, but only reviewed to ensure that the recommendation was being addressed by BNI.

APPROACH

The oversight was conducted within the guidelines of ORP PD 220.1-12, 2/12/03, "Conduct of Design Oversight". Evaluated information was collected from various BNI documents, DOE documents, interviews with BNI design staff, and a tour of the 242-A Evaporator with associated discussions with CH2M Hill Hanford Group, Inc. (CH2M Hill) staff. A full listing of the documents reviewed is provided in Appendix B. The title of personnel interviewed is provided in Appendix C.

The design review was formally conducted from May 17, 2004 to May 20, 2004. To prepare, the review team collected and reviewed applicable documentation in the week preceding the review. Also in the preceding week, an overview presentation of the FEP and TLP evaporator systems was provided by BNI. Due to the desire to minimize disruptions of the BNI design work, staff interactions were minimized in the weeks leading up to the formal review. In addition, the review team toured the 242-A Evaporator in order to familiarize the review team with evaporator operations. During the week of the formal review, team members provided written questions to BNI and interviewed various BNI staff personnel. A daily interface meeting was held to provide BNI with a status report and to identify any unresolved issues.

The review team consisted of Todd Shrader, ORP-WED, Brian Harkins, ORP-WTP, and Greg Gibbs, ORP-WTP contractor support. The approved design oversight review plan is provided in Appendix B.

Seven specific areas were identified for review. Review of these areas was determined to provide the information required to meet the design review objectives.

- Lessons learned from the 242-A Evaporator
- Safety basis compliance
- Operability of the systems
- Applicability of radiation monitoring equipment
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The methodology of review depended on the area. The lessons learned review was performed mostly with interviews with BNI and CH2M Hill staff. The operability of systems review was performed through BNI staff interviews and documentation review. The safety basis compliance and systems functionality reviews were performed through the review of system descriptions and research and technology reports along with interviews with various BNI staff. The black cell and hot cell component reviews were performed through a review of requirements documents, previous DOE assessments, engineering specifications, and BNI staff interviews. The review of the radiation monitoring equipment was discontinued after it was determined the design of the equipment was in the preliminary stage and insufficient documentation existed to perform a review. Due to limitations on the review team's time and resources, representative reviews were performed and in-depth reviews of every component were not performed.

Finally, in order to maintain a project discipline for the design review, the principles of DOE Order 413.3, Project Management for the Acquisition of Capital Assets, were utilized to prepare for, conduct, and close-out the design review. This required the development of requirements and endpoints as well as the tracking of costs and schedule for the review. These principles were only applicable to the federal staff performing the review. BNI was not assessed against DOE Order 413.3.

RESULTS

The design review team reviewed various aspects of the design process for the evaporator systems. Emphasis for the review was placed on application of contract and requirements documents to the design, application of lessons learned, and operability of the design. Vertical slices of design elements or requirements were reviewed in order to gage the overall effectiveness of the design process for the Pretreatment Facility evaporators. Due to the maturity of design, the emphasis was placed on the FEP and TLP evaporator systems. Each review area was assigned a line of inquiry number (LOI) for tracking purposes. The full discussion of each LOI is provided in Appendix A.

Incorporation of Safety Requirements – (LOI – 1)

Are the safety requirements identified in the PSAR for the FEP Evaporators correctly translated into the design documentation?

The Preliminary Safety Analysis Report (PSAR), and various implementing documents were reviewed to identify functional safety requirements for the evaporator systems and to verify the flowdown of the requirements to the design.

The mitigation and control of hydrogen is a common concern throughout all waste handling components of the Pretreatment Facility. The evaporator systems are no different, particularly for loss of power conditions. Upon the loss of power, hydrogen can potentially accumulate to above the lower flammability limit within the system components. The current mitigation strategy described in the PSAR section 3.4.1.8.3.1 is for an operator to initiate the shutdown sequence that empties the recirculation line, evaporator, and separator through the Important–To–Safety (ITS) drain valves. ITS purge air is injected below the bubblecap trays to mitigate hydrogen gas release to the vapor space during a shutdown resulting from any cause, including loss of power. However due to hydraulic constraints and limited hot cell space in the current design, the reboiler and recirculation loop can only be emptied by opening the non-ITS drain valves at the bottom of the reboiler using the power manipulator. BNI is performing analyses to determine the appropriate mitigation strategy to address the portion of reboiler and recirculation piping that is not drained by the ITS drain valves.

The Safety System Requirements Specification for Evaporator/Separator is currently on hold pending the results of reevaluation of hydrogen generation in the Newtonian evaporator/separator vessels. The potential for hydrogen retention due to solids settling and whether these solids would release hydrogen is currently under review by Central Engineering and the BNI Environmental Nuclear Safety group. Thus, the control strategy is subject to change pending the results of the reanalysis. The reevaluation was ongoing and would be completed after the completion of this review. Upon determination of the solution to address the episodic release of hydrogen for the FEP evaporator system, a PSAR change will need to be submitted addressing section 3.4.1.8.3.1 and other sections as appropriate.

Due to the potentially high radiation levels associated with the waste, hazards can exists if components fail to operate as designed. Extreme foaming of the evaporator separator vessel could overcome the capacity of de-entrainers to remove contaminants from the vapors. This can result in radioactive liquid and particulates passing through the separator and contaminating the condensate. This creates a potential direct radiation hazard to facility workers. An interlock system is planned to allow for the shutdown of the evaporator/separator feed pumps for the FEP system. Another interlock system is planned to divert the condensate and shutdown steam to the reboiler, and to stop feed to the Separator Vessel. However, implementation of the interlock design is on hold contingent on approval of an associated Authorization Basis Amendment Request (ABAR). The ABAR and supporting documents are currently under review by ORP.

While the design documentation structure and documents are prepared to translate the safety requirements into the design, the documents are still in a preliminary stage pending the results of the ongoing evaluations, thus this Line of Inquiry could not be fully reviewed. However, it was determined that the document structure and design documentation is in place ready to be revised subsequent to approval of the ABAR.

Incorporation of Research and Technology Results (LOI – 2)

Have the results of the research and technology tests reports required any changes to the design or operating strategies for the evaporators and are these being adequately pursued?

A significant amount of research and technology testing has been accomplished both at Hanford at and at the Savannah River Site that is applicable to the evaporator systems design. This information was developed to remove risk associated with the design and to provide confidence that contract requirements would be met.

Testing of the physical properties and solubility of the waste planned for processing in the FEP evaporators found that a gel formed when the pH was reduced below 12 during neutralization of the ultra-filter acid cleaning waste with ultra-filter solids wash recycle. Although sodium hydroxide was added to adjust the pH of the blended recycle, solid precipitation still occurred during the evaporation of Envelope A recycle. These solids were predominately iron hydroxides from iron that was dissolved during acid cleaning of the ultrafilters. For Envelopes B and C, evaporation did not impact the amount of solids precipitated from the solution up to the targeted sodium concentrations.

Testing for the TLP evaporator system included a range of treated feed and recycle solutions to ensure the system could produce acceptable feed for conversion to LAW glass. The objective of the testing was to demonstrate that the evaporation system could process a range of blends and produce acceptable concentrate solution for conversion to LAW glass and to identify any solid precipitates that may foul and/or plug the evaporator. A review of the data shows that in one instance the Wt% solids concentrated during evaporation exceeds the design values specified in the engineering specification Additionally, the TLP recirculation pump design condition for Wt% solids appears to be lower than the test results indicate are possible. (6.2 Wt% vice less than 4 Wt % solids specified).

The data was discussed with BNI Pretreatment Facility engineering personnel and there was agreement that it would be appropriate to verify adequate margin exists for the functional capability of the vendor selected pump to address the higher than anticipated solids content in the LAW submerged bed scrubber recycles. Review of the vendor calculations for equipment selection is currently ongoing and this item will be checked during that review.

In addition, BNI personnel were interviewed to identify the processes for review of research and technology test data by Engineering. It was confirmed that a procedure exists and has been implemented that provides a process for Engineering to provide comments and receive resolution for test reports. The test report for determination of solids concentration and precipitation had been reviewed. However, the status log was not closed as the review comments forwarded in March of 2003 indicated the fidelity of the data compared to waste data had not yet been reviewed.

Further, the research and technology tests determined that fouling and scaling were not a problem as the small amount of solids present on the tubes during the tests was easily removed. The one instance of plugging that occurred in the pilot concentrate loop was attributed to loop configuration where a low velocity/dead zone existed under certain valve settings. The design of the concentrate loop was modified and no further plugging was observed. This experience was being evaluated relative to design of the concentrate outlet line, line velocity, and operating/flushing strategies.

Two other areas investigated were the acceptability of the anti-foam agent and the decontamination factors from testing. First, testing demonstrated that approximately 500 ppm of anti-foam was effective in limiting the foam level to less than 1 foot for a liquid height of 22 ft, thus satisfying the requirement to ensure the foam level is less than 5% of the liquid height in the evaporator vessel. Second, the pilot-scale evaporator DF was greater than anticipated across the mesh pads, but not as great as required in the Engineering Specification. The vendor de-entrainment section design includes improvements in mesh pad design and the addition of three bubble cap trays to enhance the decontamination factor.

Overall the review team found that the research and technology evaporator testing was comprehensive and provided answers to the actions defined in the Flowsheet Bases, Assumptions, and Requirements document. Examples included the concentration at which solids precipitate at the WTP conditions, determining the effect of plant recycles on the evaporator process, and determining the scalability of the evaporator system. The reports did identify some issues that will potentially need to be addressed by operational strategies, such as the need to add 19M sodium hydroxide to the ultra-filtration recycle to suppress gel precipitate formation in the blended slurries before return to the evaporator.

This review identified no needed changes to the design or operating strategies for the evaporator systems based on the research and technology test reports reviewed. The observation relative to the TLP pump design specification needs to be pursued to ensure the functional capability of the selected pumps is adequate to address the higher than anticipated solids for Envelope B, tank AZ 102 simulant mixture. However, it is acknowledged that it may be possible to address this with an alternate operational strategy.

Incorporation of Contract Requirements (LOI – 3)

Have the contract requirements for waste treatment capacity been appropriately implemented for the FEP and TLP evaporator system?

The Contract requirements for waste treatment capacity were tracked through the Basis of Design Document and into the Engineering Specifications for the FEP system and the TLP system. Evaluations of the contractor design documentation produced to date indicate that the FEP and TLP systems will meet the contract waste treatment capacities for LAW and HLW. However, a newly identified constraint of 8.9 Wt% solids for hydrogen consideration was established for the Pretreatment Facility evaporators through a memorandum in December, 2003.

In December, 2003, PT Engineering established and issued bounding parameters for the FEP Evaporator for the purpose of estimating the hydrogen generation rate in the FEP separator vessel and the associated recirculation loop. This memorandum set a range of compositions with a maximum of 8.9 Wt% solids at 5.0 M sodium. Previous modeling for WTP throughput limited the evaporator concentrate to 20 Wt% solids as described in the System Description and vendor procurement specification. However, it is noted that feed conditions that could yield a concentrate condition greater than the bounding values of 8.9 Wt% solids will meet the ultrafiltration feed specification and, therefore, will by-pass the evaporator and go directly to ultrafiltration.

Waste Treatment Plant throughput previously modeled may need to be re-evaluated in light of the limits set on Wt% solids over the range of compositions specified as bounding. Process Operations intends to do this as part of the reconciliation actions for the next revision of the model. In order to properly evaluate the impact of these constraints, the Waste Treatment Plant flowsheets and the Process Engineering Material Balance should include all potential solids in the recycle streams. The results of these model revisions need to be reconciled with engineering mass balances to determine if there are situations requiring development of any new operational strategies. Additionally Process Operations needs to review the results of the new hydrogen calculations being prepared for other vessels throughout the Waste Treatment Plant to determine any model impacts with respect to throughput capacity. As part of this effort, BNI should confirm that the Contract throughputs continue to be preserved.

Incorporation of Lessons Learned (LOI – 4)

How are lessons learned from other evaporator systems around the DOE complex (such as 242-A) incorporated into the design?

The development and application of lessons learned programs is strongly encouraged by DOE and an integral part of the Integrated Safety Management System (ISMS). Lessons learned programs are an important safety mechanism to communicate the lessons (shared knowledge) from ISMS experience, assessments, and operational occurrences. Lessons learned are used to identify, communicate, and record good practices and adverse experiences with implications that may often be broader than individual corrective actions. Evaporator system design is a relatively mature technology that has been utilized throughout the DOE Complex. For example, the 242-A

Evaporator is located in the 200 East Area and has been successfully operated for over 20 years. A review was performed to ensure that the lessons learned from other DOE evaporator systems were being incorporated into the design.

The incorporation of lessons learned into the design of the Pretreatment Facility evaporator systems was reviewed and found to be adequate. This review included both interviews of BNI personnel and reviews of evaporator documentation. Lessons learned from other evaporation systems appear well integrated into the design process of the PT Facility evaporator systems. The BNI staff personnel interviewed were experienced in evaporator design and operation and very knowledgeable of events and lessons learned from other evaporator operations. The BNI staff had reviewed maintenance and outage logs and event reports from other evaporator systems.

In addition, the design and fabrication of the evaporator systems is being subcontracted to vendors, who are supplying the evaporator equipment under a design build contract. The subcontractor, Framatome ANP and its subcontractor, Swenson Technology, Inc. have considerable experience in the design of evaporator systems and nuclear applications. As it is developed, evaporator design is systematically reviewed and approved by BNI engineering staff. This arrangement has the benefit of combining evaporator industry knowledge and experience with DOE operating experience into the PT Facility evaporator system designs.

<u>System Operability</u> (LOI – 5)

Has an operational strategy been developed and incorporated into the design of the evaporators?

A key objective of the design review was to determine the operability of the evaporator systems. Although it is still early in the design process, some operational planning has occurred. For instance, key components required for operation have been developed, including: safety documentation, normal and abnormal operations scenarios, alarms piping and instrumentation diagrams, and maintenance approaches. To determine acceptability, applicable documentation was reviewed and interviews conducted with BNI personnel.

The current status of instrumentation, control strategies, and operational planning were reviewed and found to be adequate. Although not all operational aspects of the evaporator systems have been finalized, adequate planning had been performed to procure and install the evaporator systems. Development of automated and manual control strategies and final operator aids remains to be accomplished. Aiding in the development of the operational strategy, the BNI personnel interviewed were experienced in evaporator operation and very knowledgeable of the planed operational strategies for Waste Treatment Plant operations.

Finally, in order to meet the operational needs of the Department of Energy, the evaporator systems must be designed to meet the contractual requirements. The Contract requirements for waste treatment capacity were tracked through the Basis of Design Document and into the engineering specifications for the FEP system and the TLP system. Evaluations of the contractor design submittals to date indicate that the FEP and TLP systems will meet the contract waste treatment capacities for LAW and HLW.

Adequacy of Design for Black Cell Components (LOI – 6)

Have the Black Cell design requirements been included in the evaporator designs?

The separator vessels of the FEP evaporation system are located in black cells in the Pretreatment Facility. As such, extensive engineering evaluations are required to ensure the components can meet the required 40 year design life without maintenance. An extensive design review of the black cells was performed by the Office of River Protection in February, 2004. This evaporator design review did not repeat the activities of that black cell review but did ensure, through a sampling of components, that the material selection process for evaporator components was consistent with the corrective actions from the black cell review.

A representative sample component was reviewed to determine the adequacy of the design. The separator vessels must withstand corrosion and erosion degradation without testing or repair throughout the 40 year design life of the facility. A corrosion evaluation was prepared for the separator vessels indicating the required minimum material for the vessels. A review of the corrosion evaluation and the engineering specification, along with discussions with BNI design staff indicated that the material selection requirements were being incorporated into the design of the separator vessels. Further, the engineering specification clearly requires that the separator vessel be designed for a 40 year life and this requirement has been communicated to the fabrication subcontractor. It is important to note that there is one component of the separators, the demister pads, for which there is insufficient analysis and operating experience available to ensure the ability to last 40 years. Thus, the facility and separator design have been modified to allow for the replacement of these components.

Another key requirement of the Safety Requirements Document is that any vessel located in a black cell must undergo full volumetric inspection. Discussions with BNI design staff and a review of the engineering specification indicates that this requirement is captured. Although there was some ambiguity in the original August, 2003 engineering specification that was utilized for design and fabrication of the separators, a specification change notice was issued in February, 2004 clearly indicating that the entire vessel must meet volumetric inspection criteria and must be volumetrically inspected.

Adequacy of Design for Hot Cell Components (LOI – 7)

Have the Hot Cell components been adequately designed?

Due to potentially high radiation levels of the equipment, the evaporator system components located in the hot cell are designed to be remotely operated and maintenance or replacement to occur remotely. A review of the engineering specifications for hot cell components was performed to verify the remotability of the equipment. The waste feed pump, the concentrate pump, the recirculation pump, and the reboiler are located in the hot cell. These components are located on process equipment platforms that are manufactured to a high tolerance in order to aid in proper initial placement of equipment and the alignment of any needed replacement equipment. Discussions with BNI design and engineering personnel and a review of the engineering specification indicates that the equipment is being designed for remote maintenance. The engineering specification contains information for the remote actuated impact wrench utilized to remove and install fasteners. The remotability requirements have been clearly provided to the evaporator systems fabrication subcontractor.

A key component of the remotability of the hot cell components was identified by the Jumper Task Force Team. The team recommended the creation of a dimensional record program that will perform and record very precise measurements of hot cell equipment as it is fabricated and as it is installed. Many of the measurements are performed at the fabricating facility. To support this effort, an engineering specification for the dimensional record program was issued in April, 2004. The specification provided information on expected tolerances and measurement procedures. The engineering specification for the evaporators contained similar information but was issued in October, 2003 and the engineering specification for the process equipment and wall nozzle platforms was issued in May, 2004. The specifications are not fully consistent with respect to the requirements for taking the dimensional records. Clarification is required to determine the applicability of the requirements of the dimensional record program to the evaporator systems that are currently being fabricated. It is recognized that the dimensional record program specification has recently been issued and that BNI may still be evaluating its impacts and implementation.

CONCLUSIONS

It was the conclusion of the design oversight review team that the design process path being utilized by BNI for the evaporator systems was being appropriately implemented and contractual and other requirements were being met. Lessons learned from other evaporator systems are being incorporated into the design. Communication between BNI and the evaporator system subcontractor is strong and changes to the design are thoroughly reviewed by all parties. In addition, the evaporator design and fabrication efforts appear to be on schedule and will support the Pretreatment Facility construction schedule.

Two areas of concern were the incorporation of research and technology test data into the component design and the incorporation of the dimensional record program into the design process. The data from the research and technology efforts needs to be fully evaluated in the design process. Although the majority of test data indicates the evaporators are adequately designed, a few bounding conditions need to be more fully evaluated. As for the dimensional record program, BNI has indicated that it is key to the remote operability of equipment in the hot cell, particularly the replacement of equipment. A BNI policy on implementation for existing procurements, such as the evaporator systems, needs to be developed to fully appreciate the benefits of the program.

One open item, four BNI recommendations, and two DOE recommendations have been developed to address these areas of concern. The open item (OI-1) and BNI recommendations (R-1 to R-4) are to be addressed by BNI and should be resolved as soon as practicable. The

DOE recommendations (DOE-1, DOE-2) are to be addressed by ORP. The DOE recommendations will be resolved as soon as practicable but after further maturing of the design.

OPEN ITEM

OI-1: Submit a PSAR change to PSAR section 3.4.1.8.3.1 (and other sections as appropriate) to address the final mitigation strategy for an episodic release of hydrogen in the FEP system. [LOI-1]

RECOMMENDATIONS

R-1: BNI is to confirm that the WTP throughput capacity is still preserved with the imposition of the 8.9 Wt% solids limit established for the FEP evaporator separator vessel and recirculation loop. This may be confirmed during production of the next ORP flowsheet assessment deliverables using the steady state flowsheet. [LOI-3]

R-2: BNI is to review the results of new hydrogen calculations being prepared for other vessels throughout the WTP to determine any potential model impacts with respect to WTP throughput capacity. This may be performed as part of the hydrogen mitigation/pulse jet mixers trend implementation scope. [LOI-3]

R-3: The results of any model revisions need to be reconciled with engineering mass balances. Reconciliation of model revisions with engineering mass balances is routinely performed when the flowsheet assessment deliverables are generated. If it is determined that there are situations requiring any new alternative operational strategies, these may be developed during the commission phase of the project. [LOI-3]

R-4: A design and procurement strategy needs to be developed for the implementation of the dimensional record program including for procurements for which specifications have already been issued. [LOI-7]

DOE-1: Upon approval of ABAR 24590-WTP-SE-ENS-04-008, Revision 0, and the issuance of the Software Functional Specifications, ORP should confirm that the safety interlocks identified in the PSAR for the FEP Evaporators are correctly translated into the design documentation. [LOI-1]

DOE-2: Upon confirmation of the TLP pumps functional capability based on bounding solids concentration levels provided in the research and technology reports, DOE will confirm the acceptability of the design. [LOI-2]

DOE ORDER 413.3

In order to provide a structured format for the review, DOE Order 413.3 was utilized as a guide. In particular, requirements were identified and schedules developed. Also costs were tracked in order to determine the resources applied to the review. This report constitutes the CD-4 deliverable for this review.

The requirements for the performance of this review were as follows.

- The design of the evaporators of the Pretreatment Facility is to assure that the components will meet the mission need.
- The design will be performed per ORP PD 220.1-12, 2/12/03, "Conduct of Design Oversight".
- The design review schedule will be maintained as described in Table 2.

The first two requirements were fully met by the review. However, the third requirement was not met as the final report was not issued per the schedule. The full schedule is provided in Table 1 of Appendix D.

The endpoint of the design review is the issuance of this report. Verification of closure of the BNI open item or recommendations or the ORP recommendations will be tracked under the ORP Consolidated Action Reporting System.

Finally, although formal time tracking was not performed for this review, an estimate was developed by the participants. To support this review, BNI expended approximately 75 man-hours ($5,000). To perform the review, ORP expended approximately 200 man-hours ($14,000). Thus, the cost to perform this review was estimated to be approximately $19,000.

Appendix A

Attached are the full lines of inquires and the associated discussions.

Line of Inquiry (LOI – 1):

Are the safety requirements identified in the PSAR for the FEP Evaporators correctly translated into the design documentation?

Discussion of Review:

The PSAR was reviewed to identify the functional safety requirements for the Evaporator System. These were then reviewed against the Software Functional Specifications and P&IDs for control functions designed to implement the safety functional requirements. The results of the review are as follows:

The PSAR identifies the control strategies listed below.

With respect to hydrogen control for the Evaporators:

On the loss of power, hydrogen can potentially accumulate to above the lower flammability limit within the system components. The current mitigation strategy described in the PSAR section 3.4.1.8.3.1 is for an operator to initiate the shutdown sequence that empties the recirculation line, evaporator, and separator through the Important–To–Safety (ITS) drain valves. ITS purge air is injected below the bubblecap trays to mitigate hydrogen gas release to the vapor space during a shutdown resulting from any cause, including loss of power. However due to hydraulic constraints and limited hot cell space in the current design, the reboiler and recirculation loop can only be emptied by opening the non-ITS drain valves at the bottom of the reboiler using the power manipulator. BNI is performing analyses to determine the appropriate mitigation strategy to address the portion of reboiler and recirculation piping that is not drained by the ITS drain valves.

The Safety System Requirements Specification for Evaporator/Separator is currently on hold pending the results of reevaluation of hydrogen generation in the Newtonian evaporator/separator vessels. The potential for hydrogen retention due to solids settling and whether these solids would release hydrogen is currently under review by Central Engineering and the BNI Environmental Nuclear Safety group. Thus, the control strategy is subject to change pending the results of the reanalysis, which is ongoing. Upon determination of the solution to address the episodic release of hydrogen for the FEP evaporator system, a PSAR change will need to be submitted addressing section 3.4.1.8.3.1 and other sections as appropriate.

With respect to removal of contaminants from evaporator vapors:

Extreme foaming of the evaporator separator vessel contents could overcome the capacity of de-entrainers to remove contaminants from the vapors resulting in radioactive liquid and particulates passing through the piping and contaminating the condensate. This creates a potential direct radiation hazard to facility workers. Interlocks credited to shutdown the evaporator/separator feed pumps are provided for FEP-SEP-0001A/B. The P&ID – PTF Waste Feed Evaporation Process System Evaporated Feed Vessels, FEP-VSL-000017A/B drawing 24590-PTF-M6-FEP-00001 refers to the Software Functional Specification 24590-PTF-3PS-PPJ-T001 for the permissives and interlocks for important to safety system functions. The Safety System Requirements Specification for Evaporator/Separator Shutdown Interlocks is 24590-PTF-3PS-PPJ-T0016. Another interlock system is incorporated to divert the condensate and shutdown steam to the reboiler, and to stop feed to the Separator Vessel. These documents are preliminary and on hold pending approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-04-008, Revision 0.

The ABAR proposes to update the Waste Feed Evaporation Process System foaming/carryover events from Safety Design Class/Seismic Category-III to Additional Protection Class/Seismic Category-III. Instead of shutting down the separator feed pump on high radiation in the process condensate the design change discussed in the ABAR would recycle the contaminated condensate to the separator. In addition, the safety classification of the control strategy would change from SDC to APC based on a revised dose calculation and implementation of the SRD Safety Criterion 1.0-6. The ABAR and supporting documents are currently under review by the Office of River Protection.

With respect to process and steam condensate monitoring and interlocks:

These controls ensure the operability and interlock instrumentation of the FEP reboilers by detecting and diverting contaminated steam and condensate from the evaporator reboiler to the plant wash and disposal system. Without these controls contaminated steam or condensate could cause exposure to facility workers above the RES.

Like the other control strategies, the Software Functional Specification is preliminary and on hold.

While the design documentation structure and documents are prepared to translate the safety requirements into the design, the documents are still in a preliminary stage pending the results of the ongoing evaluations discussed above so the objective of this item could not be satisfied.

Open Items/Recommendations:

Open Items

OI-1: Submit a PSAR change to PSAR section 3.4.1.8.3.1 (and other sections as appropriate) to address the final mitigation strategy for an episodic release of hydrogen in the FEP system.

Recommendations

DOE-1: Upon approval of ABAR 24590-WTP-SE-ENS-04-008, Revision 0, and the issuance of the Software Functional Specifications, ORP should confirm that the safety interlocks identified in the PSAR for the FEP Evaporators are correctly translated into the design documentation.

Line of Inquiry (LOI – 2):

Have the results of the research and technology tests reports required any changes to the design or operating strategies for the evaporators and are these being adequately pursued?.

Discussion of Review:

This evaluation consisted of reviewing the following research and technology test reports: WSRC-TR-2003-00212, Rev 0, Waste Feed Evaporation: Physical Properties and Solubility ; (U); WSRC-TR-2003-00561, Rev. 0, WTP Pilot-Scale Evaporation Tests (U); WSRC-TR-2003-00119, Rev. 0, Treated LAW Feed Evaporation Physical Properties and Solubility Determination (U); and 24590-PTF-RPT-RT-03-001, Rev. 0, Closure Report for R & T Evaporator Studies.

With respect to the Waste Feed Evaporator, the role of the waste feed evaporator has changed from concentration of waste feed to concentration of plant recycle streams. The Waste Feed Evaporation: Physical Property and Solubility test found that solids precipitated during addition of the acid cleaning solution to the ultrafilter recycle. The recycle solution formed a gel when the ultra-filter acid cleaning waste was neutralized with the ultra-filter solids wash recycle, reducing the pH below 12. Sodium hydroxide was added to adjust the pH of the blended recycle. Evaporation of Envelope A recycle resulted in solids precipitation, predominately iron hydroxides from iron that was dissolved during acid cleaning of the ultrafilters, but also including thermonatrite, natrophosphate, natroxalate, sodium nitrate, sodium nitrite and lithium aluminum carbonate hydroxide hydrate. This was in addition to the gibbsite and bayerite present prior to evaporation. For Envelopes B and C, evaporation did not impact the amount of solids precipitated from the solution up to the targeted sodium concentrations.

With respect to Treated LAW Feed Evaporation, a range of treated feed and recycle solutions were concentrated to produce acceptable feed for conversion to LAW glass. The data reported below are contained in the Appendix A Figures of WSRC-TR-2003-00119, Rev. 0. Over a range of simulates, for Envelope A the highest value reported for Wt% solids (Mixture(s) SM-55-02/09), total insoluble solids (suspended) ranged from 0/0.7 to 2.3/2.4 Wt%, precipitated solids ranged from 0/0 to 0/1 Wt % over a range of sodium molarity of 2 to 9M. For Envelope B for AZ101 the, the total suspended solids ranged from 0 to 3.8 Wt% over a sodium molarity of 1.4 to 8.5M; precipitated solids ranged from 0 to 2.4 Wt%. For Envelope B for AZ102 the insoluble solids (suspended) ranged from 0 to 6.2 Wt% both over a range of sodium molarity of 1.5 to 8.3M; the precipitated solids range from 0 to 5.5 Wt%. For Envelope A the greatest number (10-13) of solids were found at sodium molarities of 8.0-8.5M. For Envelope B, 7 different solids were found at 5.5M sodium. For Envelope C, the greatest number (7) of solids was found at 2M sodium with 6 solids identified at 8M sodium.

The objective of the test was to demonstrate that the evaporation system can process a range of blends and produce acceptable concentrate solution for conversion to LAW glass and to identify any solid precipitates that may foul and/or plug the evaporator. A review of the data above shows that in one instance the Wt% solids concentrated during evaporation exceeds the design values specified in Specification 24590-PTF-3PS-MEVV-TP0001, Engineering Specification for Forced Vacuum Evaporator System. The TLP recirculation pump design condition is specified as less than 4Wt% solids. The simulant test results show solids concentrations as high as 6.2Wt%.

The above data was discussed with the Pretreatment Facility Lead engineer. The engineer agreed it would be appropriate to verify adequate margin existed for the functional capability of the vendor selected pump to address the higher than anticipated solids content in the SBS LAW recycles. Review of vendor calculations for equipment selection is currently ongoing and this item will be checked during that review. Likewise the TLP concentrate pumps have a design condition specified as less than 4 Wt% solids.

Personnel from process engineering were interviewed to determine what processes existed for review of research and technology test data by Engineering. It was confirmed that a procedure existed and implemented a reasonable process for Engineering comment and comment resolution and identification of actions. The test report for determination of solids concentration and precipitation cited above had in fact been reviewed. The status log was not closed as the review comments forwarded in March of 2003 indicated the fidelity of the data compared to waste data had not yet been reviewed.

The research and technology tests determined that fouling and scaling were not a problem as the small amount of solids present on the tubes during the tests were easily removed by wiping. While there was a plug that occurred in the concentrate loop that contained bayeritye, kogarkoite, natrophosphate, nitratine, thermonatrite, trona and lithium aluminum carbonate hydroxide hydrate it was attributed to loop configuration where a low velocity/dead zone existed under certain valve settings. The concentrate line was reconfigured and no further plugage was observed. This experience was being evaluated relative to design of the concentrate outlet line, line velocity, and operating/flushing strategies.

The recommended anti-foam agent was found to be acceptable. Around 500 ppm of antifoam was effective to control the foam level to less than 1 foot for a liquid height of 22 ft satisfying the requirement to ensure the foam level is less than 5% of the liquid height in the evaporator vessel. The Pilot-Scale evaporator tests characterized the fluid properties such as liquid and slurry density, solubility, viscosity, rheology, solids and particle size distribution, vapor pressure, and thermodynamic properties.

The Pilot-Scale evaporator decontamination factor was greater than anticipated across the mesh pads, but not as great as required in the Engineering Specification. The vendor de-entrainment section design includes improvements in mesh pad design and the addition of three bubble cap trays to enhance the decontamination factor.

Overall the research and technology evaporator testing was comprehensive and has provided answers to the actions defined in the Flowsheet Bases, Assumptions, and Requirements document, 24590-WTP-RPT-PT-02-005, Rev 2. For example determining the concentration at which solids precipitate at the WTP conditions, determining the effect of plant recycles on the evaporator process, and determining the scalability of the evaporator system. The reports cited above identified some issues that will potentially need to be addressed by operational strategies. For example, gel formation requiring the addition of 19M sodium hydroxide to the ultra-filtration recycle to maintain a pH of 13 in the blended slurries before return to the evaporator. This review identified no needed changes to the design or operating strategies for the evaporator systems based on the research and technology test reports reviewed. The observation relative to the TLP pump design specification needs to be pursued to ensure the functional capability of the selected pumps is adequate to address the higher than anticipated solids for Envelope B, tank AZ 102 simulant mixture. It is acknowledged that it may be possible to address this with an operational strategy.

Open Items/Recommendations:

Open Items

None

Recommendations

DOE-2: Upon confirmation of the TLP pumps functional capability based on bounding solids concentration levels provided in the research and technology reports, DOE will confirm the acceptability of the design.

Line of Inquiry (LOI – 3):

Have the contract requirements for waste treatment capacity been appropriately implemented for the FEP and TLP evaporator system?

Discussion of Review:

The Contract requirements for waste treatment capacity were tracked through the Basis of Design Document and into the Engineering Specifications for the FEP system and the TLP system. Evaluations of the contractor design submittals to date, indicate that the FEP and TLP systems will meet the contract waste treatment capacities for LAW and HLW; however determination of the WTP throughput capacity by modeling should be confirmed based on an upper limit of 8.9 Wt% solids established in December, 2003 as bounding to address hydrogen concerns.

A new constraint for the process was documented through a memorandum (CCN: 074569). In December, 2003, PT Engineering established and issued bounding parameters for the FEP Evaporator for the purpose of estimating hydrogen generation rate in the FEP separator vessel and the associated recirculation loop. This memorandum set a range of compositions of 5M sodium and 8.9 Wt% solids, 8.0M sodium and 2.0 wt% solids, 5.8M sodium and 3.2Wt% solids and 6.9M sodium and 2.5 Wt% solids for LAW A/D or LAW B/D. For LAW Envelope C/D the feed contract minimum LAW C at contract maximum entrained solids was specified at 6.0M sodium and 5.2Wt% solids. However, it is noted that feed conditions that could yield a concentrate condition greater than the bounding values of 8.9 Wt% solids will meet the ultrafiltration feed specification and, therefore, will by-pass the evaporator and go directly to ultrafiltration.

Previous modeling for WTP throughput limited the evaporator concentrate to 20 Wt% solids as described the in System Description and vendor procurement specification. WTP throughput previously modeled may need to be re-evaluated in light of the limits set on Wt% solids over the range of compositions specified as bounding. Process Operations intends to do this as part of their reconciliation actions for the next revision of the model. In order to properly evaluate the impact of these constraints, the WTP flowsheets and the Process Engineering Material Balance should include all potential solids in the recycle streams. The results of these model revisions need to be reconciled with Engineering mass balances to determine if there are situations requiring development of any new operational strategies. Additionally Process Operations needs to review the results of new hydrogen calculations being prepared for other vessels throughout the WTP to determine any model impacts with respect to WTP throughput capacity.

As part of this effort, BNI should confirm that the contract throughputs continue to be preserved. Additionally the appropriateness of establishing this information via memorandum without an approved calculation as a basis should be reviewed given that it is a design input into the hydrogen generation calculations. (Note the PT Engineering group has indicated it intends to prepare a calculation providing the technical basis for these bounding limits; the hydrogen calculation being prepared for Newtonian vessels identifies the information as an assumption requiring verification).

Open Items/Recommendations:

Open Items

None

Recommendations

R-1: BNI is to confirm that the WTP throughput capacity is still preserved with the imposition of the 8.9 Wt% solids limit established for the FEP evaporator separator vessel and recirculation loop. This may be confirmed during production of the next ORP flowsheet assessment deliverables using the steady state flowsheet.

R-2: BNI is to review the results of new hydrogen calculations being prepared for other vessels throughout the WTP to determine any potential model impacts with respect to WTP throughput capacity. This may be performed as part of the hydrogen mitigation/pulse jet mixers trend implementation scope.

R-3: The results of any model revisions need to be reconciled with engineering mass balances. Reconciliation of model revisions with engineering mass balances is routinely performed when the flowsheet assessment deliverables are generated. If it is determined that there are situations requiring any new alternative operational strategies, these may be developed during the commission phase of the project.

Line of Inquiry (LOI – 4):

How are lessons learned from other evaporator systems around the DOE complex (such as 242-A) incorporated into the design?

Discussion of Review:

Lessons learned programs are an important safety mechanism to communicate the lessons (shared knowledge) from work experiences, assessments, and operational occurrences. Lessons learned are a key component of the Integrated Safety Management System (ISMS) and ISMS implementation is a contract requirement. Sharing experiences benefits the future work of the organization. Lessons learned are used to identify, communicate, and record good practices and adverse experiences with implications that may often be broader than individual corrective actions. This is intended to make management, supervisors, subject matter experts, and workers aware of experiences that should be replicated or avoided in future work. Lessons learned programs should also search beyond the local organization for experiences of other DOE facilities and sites, private industry, and other governmental organizations involved with similar work, hazards, or technical components. Internal and external experience should be analyzed for local implications and communicated to relevant local audiences to aid in the performance of future work.

The incorporation of lessons learned into the design of the Pretreatment Facility evaporator systems was reviewed and found to be adequate. This review included both interviews of BNI personnel and review of evaporator documentation. Evaporator system design is a relatively mature technology that is utilized throughout industry and the DOE Complex. For example, the 242-A Evaporator is located in the 200 East Area of the Hanford Site and has been successfully operated for over 20 years. Lessons learned from this and other evaporation systems appear well integrated into the design process at the Waste Treatment Plant. The BNI personnel interviewed were experienced in evaporator design and operation and very knowledgeable of events and lessons learned from other evaporator operations. The personnel had reviewed maintenance and outage logs and event reports from other evaporators. Also, design staff included personnel with direct experience with the 242-A Evaporator. Finally, much of the research and technology efforts build off of lessons learned from the evaporator systems at the Savannah River Site.

The design of the Pretreatment Facility evaporator systems is being subcontracted to vendors, who are supplying the evaporator equipment under a design build contract. However, integrating the vendor supplied components into the overall design of the Pretreatment Facility is still the responsibility of BNI. Thus, the design is being systematically reviewed, approved, and incorporated into the Pretreatment Facility design by BNI personnel as it is developed. The evaporator subcontractor, Framatome ANP, and its subcontractor, Swenson Technology, Inc. have considerable experience in the design of evaporator systems and nuclear applications. This arrangement has the benefit of incorporating evaporator design industry knowledge and experience into the Pretreatment Facility designs. The reviewer found evidence that Framatome's comments were being incorporated into the evaporator designs.

Open Items/Recommendations:

Open Items

None

Recommendations

None

Line of Inquiry (LOI – 5):

Has an operational strategy been developed and incorporated into the design of the evaporators?

Discussion of Review:

A key objective of the design review was to determine the operability of the evaporator systems. In order to provide a basis for review, the five elements of 10 CFR 830.122 (f), Criterion 6, Performance Design, were utilized. The five elements are:

(1) Design items and processes using sound engineering/scientific principles and appropriate standards.
(2) Incorporate applicable requirements and design bases in design work and design changes.
(3) Identify and control design interfaces.
(4) Verify or validate the adequacy of design products using individuals or groups other than those who performed the work.
(5) Verify or validate work before approval and implementation of the design.

Although it is still early in the design process, some operational planning has occurred. For instance, key components required for operation have been developed and documented. These include the following:

(1) Safety requirements
(2) Normal and abnormal operations scenarios
(3) Operating trips
(4) Alarms
(5) Set point controls
(6) Piping & Instrumentation Diagram's (P&ID)
(7) Maintenance approaches
(8) Decontamination approaches

To determine acceptability, applicable documentation was reviewed and interviews were conducted with BNI personnel.

The current status of instrumentation, control strategies, and operational planning were reviewed and found to be adequate. Although not all operational aspects of the evaporator systems have been finalized, adequate planning had been performed to procure and install the evaporator systems. Development of automated and manual control strategies and final operator aids remains to be accomplished. Aiding in the development of the operational strategy, the BNI personnel interviewed were experienced in evaporator operation and very knowledgeable of the planed operational strategies for the Pretreatment Facility.

Finally, in order to meet the operational needs of the Department of Energy, the evaporators must be designed to meet the contractual requirements. A brief review of available information was performed and discussions with BNI personnel were held to verify this aspect of operability.

The Contract requirements for waste treatment capacity were tracked through the Basis of Design Document and into the Engineering Specifications for the FEP system and the TLP system. Evaluations of the contractor design submittals to date indicate that the FEP and TLP systems will meet the contract waste treatment capacities for LAW and HLW.

Open Items/Recommendations:

Open Items

None

Recommendations

None

Line of Inquiry (LOI – 6):

Have the Black Cell design requirements been included in the evaporator designs?

Discussion of Review:

The Waste Feed Evaporation Process (FEP) system and the Treated Low Activity Waste Evaporation Process Feed (TLP) system have components located in the black cells, the hot cell, and other controlled areas of the Pretreatment Facility. The separator vessels of the FEP and TLP evaporation system are located in black cells P-0106 and P-0117, respectively. As such, extensive engineering evaluations are required to ensure the components can meet the required 40 year design life without maintenance or access. The Design Oversight Report on Black Cell Design Adequacy was issued by the Office of River Protection in February, 2004. The report detailed recommendations and open items on all aspects of black cell design. In particular, the report details a number of open items concerning material selection for black cell components. This evaporator design review did not repeat the activities of that black cell review but did ensure, through a sampling of components, that the material selection process for evaporator components was consistent with the corrective actions from the black cell review.

A representative black cell component was reviewed to determine the adequacy of the design and material selection; in this case, the FEP separator vessels. The waste feed evaporator separator vessels (FEP-SEP-00001 A/B) must withstand corrosion and erosion degradation without testing or repair throughout the 40 year design life of the facility. A corrosion evaluation (24590-PTF-N1D-FEP-00007) was prepared for the separator vessels indicating the required minimum acceptable material for the vessels. For these separators, the four acceptable materials were 304L Steel, 316L Steel, 6% Mol, and Alloy 22. The applicable engineering specifications (24590-PTF-3PS-MEVV-TP001 and 24590-WTP-3PS-MV00-TP001) require that the material for the separators be furnished to the specification and grade shown on the mechanical data sheet. The mechanical data sheet for the separators (24590-PTF-MVD-FEP-00006) lists the materials of selection as 304 SS with a maximum carbon content of 0.030% for welded components (this carbon content is indicative of 304 L stainless steel). This documentation along with discussions with BNI design staff indicates that the material selection requirements are being incorporated into the design of the separator vessels.

The corrosion evaluation clearly states that the separators cannot be maintained or replaced for the 40 year design life. This design criterion is carried into the engineering specification and mechanical data sheet, which communicates the requirement to the separators fabrication subcontractor, Framatome ANP. However, it is important to note that there is one component of the separators, the demister pads, for which there is insufficient analysis and operating experience available to ensure the ability to last 40 years. Thus, the black cell and separator designs have been modified to allow for the replacement of these components through accesses into the black cells directly above the separators. The mechanical data sheet also notes that the demister pads are replaceable.

A key requirement of the Safety Requirements Document (24590-WTP-SRD-ESH-01-001-02, Appendix H, section 6.0) is that any vessel located in a black cell must undergo full volumetric inspection of the welds in the primary confinement boundary to ensure that weld defects are discovered and repaired. Discussions with BNI design staff and a review of the engineering specification indicates that this requirement was captured. Although there was some ambiguity in the original August, 2003 engineering specification that was utilized for design and fabrication of the separators, a specification change notice (24590-WTP-3PN-MV00-00006) was issued in February, 2004 clearly indicating that the entire vessel must meet volumetric inspection criteria and must be volumetrically inspected, preferably with radiography.

Because material selection is crucial to ensuring the 40 year life of the equipment, this review concentrated on the separator material selection and the acceptance inspections. The material selection and design process used to communicate this information to the fabrication subcontractor were found to be adequate with no open items or recommendations developed for this line of inquiry.

Open Items/Recommendations:

Open Items

None

Recommendations

None

Line of Inquiry (LOI – 7):

Have the Hot Cell components been adequately designed?

Discussion of Review:

Due to potentially high radiation levels of the equipment, some of the components of the Waste Feed Evaporation Process (FEP) system and the Treated Low Activity Waste Evaporation Process Feed (TLP) evaporator system are located in the hot cell. These components are designed to be remotely operated and for maintenance or component replacement to occur remotely. A review of the engineering specification for the hot cell process equipment and wall nozzle platforms (24590-PTF-3PS-PIH-T0002) was performed to verify the remotability of the equipment. The waste feed pump, the concentrate pump, the recirculation pump, and the reboiler are located in the hot cell on process equipment platforms that are manufactured to a high tolerance in order to aid in proper initial placement of equipment and the alignment of any needed replacement equipment. In addition, discussions with BNI design and engineering personnel and a review of the process equipment and wall nozzle platforms engineering specification indicates that the equipment is being designed for remote maintenance. The engineering specification for the evaporator systems (24590-PTF-3PS-MEVV-TP001) contains detailed information for the equipment platform layout configuration and the hot cell remote impact wrench to ensure remote operability once installed in the hot cell. The remotability requirements have been provided to the evaporator systems fabrication subcontractor, Framatome, ANP.

A key component of the remotability of the hot cell components was identified by the Jumper Task Force Team. The team recommended the creation of a dimensional record program that will perform and record very precise measurements of hot cell equipment as it is fabricated and as it is installed. Many of the measurements are performed at the fabrication facility. To support this effort, an engineering specification for the dimensional record program (24590-WTP-3PS-PP00-T0002) was issued in April, 2004. The specification provided information on expected tolerances and measurement procedures. The engineering specification of the evaporators (24590-PTF-3PS-MEVV-TP001) contained similar information but was issued in October, 2003 and the engineering specification for the process equipment and wall nozzle platforms (24590-PTF-3PS-PIH-T0002) was issued in May, 2004. The specifications are not fully consistent with respect to the requirements for taking the dimensional records. For example, the process equipment and wall nozzle platform engineering specification states that measurements shall be calibrated to a precision which represents a minimum of 20% of the tolerance being measured. The evaporator system engineering specification states scales shall be calibrated to 0.01 inch and micrometers to 0.001 inch. The dimensional records program engineering specification states measurements are to be performed to a 10% accuracy limit. Thus, for a 1/16 inch dimension, the measurement tolerance is plus or minus 0.006 inch. Although all of these requirements may overlap for some dimensions, clarification is required to determine the appropriate measurement tolerance and accuracy requirement. The engineering specification for the dimensional records program appears to provide a requirement for all hot cell components. A review should be performed to verify the dimensional records from evaporator system equipment or components fabricated prior to the issuance of the dimensional records program specification meet the new requirements. It is recognized that the dimensional record program specification has recently been issued and that BNI may still be evaluating its impacts and implementation.

Open Items/Recommendations:

Open Items

None

Recommendations

R-4: A design and procurement strategy needs to be developed for the implementation of the Dimensional Record Program including for procurements for which specifications have already been issued.

Appendix B

The following is the list of documents reviewed during the performance of this design oversight.

1. Authorization Basis Amendment Request, "24590-WTP-SE-ENS-04-008, Control Strategy and Classification Changes for Pretreatment Evaporator Separator Foaming Event", CCN 085304, issued April 14, 2004.

2. BNI Memorandum, "Bounding Parameters for the FEP Evaporator", CCN 074569, issued December 22, 2003.

3. Calculation Sheet, "Calculation of Hydrogen Generation Rates", 24590-WTP-M4C-V11T-00004, Revision A, issued March 18, 2004.

4. Calculation Sheet, "Process Data for Waste Feed Evaporator, Fed Vessels and Feed/Concentrate Pumps", 24590-PTF-MEC-FEP-00001, Revision B, issued September 5, 2002.

5. "Closure Report for R & T Evaporator Studies", 24590-PTF-RPT-RT-03-001, Revision. 0, issued February 2, 2004.

6. Comment Resolution Form for Framatome Technical Document on the HEP System.

7. Corrosion Evaluation, FEP-SEP-00001A/B, Waste Feed Evaporator Separator Vessels", 24590-PTF-N1D-FEP-00007, Revision 4, issued May 18, 2004.

8. Design Change Application, "Evaporator Feed and Recycle Management", 24590-PTF-DCA-PR-01-002, Revision. 0, issue April 18, 2002.

9. "Documented Safety Analysis for the 242-A Evaporator", HNF-14755, Revision. 0, issued November 14, 2003.

10. Engineering Specification, "Cesium Nitric Acid Recovery Forced Circulation Vacuum Evaporation System", 24590-PTF-3PS-MEVV-T0002, Revision 2, issued April 26, 2004.

11. Engineering Specification, "Forced Circulation Vacuum Evaporator System" 24590-PTF-3PS-MEVV-T0001, Revision 1, issued May 5, 2003.

12. Engineering Specification, "Forced Circulation Vacuum Evaporator System" 24590-PTF-3PS-MEVV-TP001, Revision 1, issued October 31, 2003.

13. Engineering Specification, "Pressure Vessel Design and Fabrication" 24590-WTP-3PS-MV00-TP001, Revision 1, issued August 13, 2003.

14. Engineering Specification, "Process Equipment and Wall Nozzle Platforms", 24590-WTP-3PS-PIH-T0002, Revision 0, issued May 12, 2004.

15. Engineering Specification, "Welding or Pressure Vessels, Heat Exchangers and Boilers", 24590-WTP-3PS-MVB2-T0001, Revision 1, issued February 27, 2003.

16. "Flowsheet Bases, Assumptions, and Requirements", 24590-WTP-RPT-02-005, Revision 2, issued October 21, 2003.

17. Framatome ANP Drawing # 5030498E Revision 00, "Evaporator Project #1 Process Flow Diagram FEP A System", 24590-QL-POA-MEVV-00001-01-00270, Revision B.

18. Framatome ANP Drawing # 5030614E Revision 00, "Evaporator Project #1 Process Flow Sheet FEP A System", 24590-QL-POA-MEVV-00001-01-00271, Revision B.

19. Framatome ANP Drawing # 5035016E Revision 00, "Evaporator Project #1 Process Flow Diagram FEP B System", 24590-QL-POA-MEVV-00001-01-00283, Revision A.

20. Framatome ANP Drawing # 5035017E Revision 00, "Evaporator Project #1 Process Flow Sheet FEP B System", 24590-QL-POA-MEVV-00001-01-00284, Revision A.

21. Framatome ANP Drawing # 5042681D, Revision 00, "Logic Diagram – FEP – A – Master Sequence Flow Chart", 24590-QL-POA-MEW-00001-01-00552, Revision A.

22. Framatome ANP Drawing # 5042682D, Revision 00, "Logic Diagram – FEP – A – Pull Vacuum, Fill Sequences Flow Chart", 24590-QL-POA-MEW-00001-01-00553, Revision A.

23. Framatome ANP Drawing # 5042683D, Revision 00, "Logic Diagram – FEP – A – Condense (Run) Sequences Flow Chart", 24590-QL-POA-MEW-00001-01-00554, Revision A.

24. Framatome ANP Drawing # 5042684D, Revision 00, "Logic Diagram – FEP – A – Miscellaneous Sequences Flow Chart", 24590-QL-POA-MEW-00001-01-00555, Revision A.

25. Framatome ANP Drawing # 5042685D, Revision 00, "Logic Diagram – FEP – A – Shutdown Sequences Flow Chart", 24590-QL-POA-MEW-00001-01-00556, Revision A.

26. Framatome ANP Presentation, "PTF Evaporator Project MEVV-00001, 60% Design Review – Early Delivery Items", March 2, 2004.

27. Framatome ANP Technical Document, "Hanford Evaporator Project #1 – Decontamination Factor Calculation", 24590-QL-POA-MEW-00001-04-02, Revision 00B.

28. Framatome ANP Technical Document, "Hanford Evaporator Project #1 – Evaporator Mass and Energy Balance", 24590-QL-POA-MEW-00001-04-04, Revision 00B.

29. Framatome ANP Technical Document, "Hanford Evaporator Project #1 – Sizing Calculations – Separator Vessel", 24590-QL-POA-MEVV-00001-04-00012, Revision 00A.

30. Framatome ANP Technical Document, "HEP #1 Equipment Design Conditions", 24590-QL-POA-MEVV-00001-14-00002, Revision 00A.

31. Framatome ANP Technical Document, "HEP #1 System Description", 24590-QL-POA-MEW-00001-08-01, Revision 00B.

32. Mechanical Data Sheet: Vessel, "Waste Feed Evaporator Separator Vessel FEP-SEP-00001A", 24590-PTF-MVD-FEP-00006, Revision 1, issued April 29, 2004.

33. "Operations Requirements Document", 24590-WTP-RPT-OP-01-001, Revision 2, issued May 2, 2003.

34. Piping and Instrumentation Diagram, "PTF Treated LAW Evaporation Process System Condensers & Condensate Collection TLP-VSL-00002", 24590-PTF-M6-TLP-00002, Revision. 1, issued February 6, 2004.

35. Piping and Instrumentation Diagram, "PTF Treated LAW Evaporation Process System Separator TLP-SEP-00001", 24590-PTF-M6-TLP-00003, Revision. 1, issued February 6, 2004.

36. Piping and Instrumentation Diagram, "PTF Waste Feed Evaporation Process System Evaporation Process System Evaporator Feed Vessels FEP-VSL-00017A/B", 24590-PTF-M6-FEP-00001, Revision. 1, issued February 9, 2004.

37. Piping and Instrumentation Diagram, "PTF Waste Feed Evaporation Process System Separator FEP-SEP-00001A", 24590-PTF-M6-FEP-00002, Revision. 1, issued February 6, 2004.

38. Piping and Instrumentation Diagram, "PTF Waste Feed Evaporation Process System Condensers & Condensate Collection FEP-VSL-00005", 24590-PTF-M6-FEP-00003, Revision. 1, issued February 6, 2004.

39. Piping and Instrumentation Diagram, "PTF Waste Feed Evaporation Process System Separator FEP-SEP-00001B", 24590-PTF-M6-FEP-00004, Revision. 1, issued February 6, 2004.

40. Piping and Instrumentation Diagram, "PTF Waste Feed Evaporation Process System Condensers", 24590-PTF-M6-FEP-00005, Revision. 1, issued February 6, 2004.

41. "Preliminary Safety Analysis Report to Support Construction Authorization; PT Facility Specific Information", 24590-WTP-PSAR-ESH-01-002-02, Revision 1, issued September 30, 2003.

42. Purchase Order Submittal, "Hanford Evaporator Project #1 – Evaporator Mass and energy Balance", 24590-QL-POA-MEVV-00001-04-04, Revision 00B, issued April 2, 2004.

43. "Quality Assurance Criteria – Criterion 6 – Performance/Design", 10 CFR 830.122 (f).

44. Research and Technology Test Report, "Treated LAW Feed Evaporation Physical Properties and Solubility Determination (U)", WSRC-TR-2003-00119, Revision. 0, March, 2003.

45. Research and Technology Test Report, "Waste Feed Evaporation: Physical Properties and Solubility; (U)", WSRC-TR-2003-00212, Revision 0, issued May 13, 2003.

46. Research and Technology Test Report, "WTP Pilot-Scale Evaporation Tests (U)", WSRC-TR-2003-00561, Revision. 0 March, 2004.

47. "Safety Requirements Document, Volume II", 24590-WTP-SRD-ESH-01-001-02, Revision 3h, issued May 12, 2004.

48. Safety System Requirement Specification, "Evaporator/Separator Level Interlock", 24590-PTF-3PS-PPJ-T0016, Revision A

49. Software Functional Specification, "PTF Evaporator Train", 24590-PTF-3PS-TLP-T0002, Revision A, issued January 5, 2004.

50. Software Functional Specification, "PTF Treated LAW Evaporation Process (TLP) System", 24590-PTF-3PS-TLP-T0001, Revision A, issued May 17, 2004.

51. Specification Change Notice "Engineering Specification for Pressure Vessel Design and Fabrication", 24590-WTP-3PS-MV00-T00001, Revision 1, issued February 6, 2004.

52. System Description, "System Description for Treated LAW Evaporation Process (TLP)", 24590-PTF-3YD-TLP-00001, Revision 0, issued October 3, 2002.

53. System Description, "System Description for Waste Feed Evaporation Process (FEP)", 24590-PTF-3YD-FEP-00001, Revision 0, issued September 24, 2002.

54. System Description Change Notice # 24590-PTF-3YN-FEP-00001, "System Description for Waste Feed Evaporation Process (FEP)", 24590-PTF-3YD-FEP-00001, Rev.0, issued March 19, 2004.

55. "Technical Safety Requirements for the 242-A Evaporator", HNF-15279, Revision. 0, issued November 14, 2003.

56. "Waste Treatment Plant Black Cell Design Adequacy Oversight Report", D-03-DESIGN-006, ORP letter 04-WEC-005, issued February 11, 2004.

3.5 How were corrosion/erosion allowances determined, including any limitations on fluid velocity, particle size, particle hardness?
3.6 What provisions are made in the piping stress analyses to account for residual stresses due to installation?
3.7 Are specific layout criteria imposed on black cell components to mitigate potential failure mechanisms (such as for piping systems)?
3.8 Are there any provisions or capability for temporary access into the black cells for any purpose?
3.9 What types of design models (e.g. piping, thermal stress, load stress) are used in the BNI design process? Do these models adequately represent the expected operational conditions (e.g. chemical, thermal, load stress) of the respective black cell process components?
3.10 What design models are used for vessel and piping design? What verification has BNI conducted on these models?
3.11 Are there provisions to clear potential pipe or component plugging?
3.12 What level of contingency planning, in terms of identification of equipment redundancy and spares, has been identified in the development of the design?
3.13 Identify the process piping spares that currently exist for each system that is entirely enclosed, or partially enclosed, in a black cell.
3.14 Identify the process piping spares that exist between major facilities (e.g. Pretreatment and HLW Vitrification and Pretreatment and LAW Vitrification).
3.15 Is there an experience base that supports the use of these design concepts with the operational limitations/requirements identified?
3.16 How is BNI documenting operational limitations identified in the materials selection process and design process, and how are these limitations/procedures to be captured in the operational specifications for the facility?
3.17 What are the operational risks that have been identified in the Risk Register that are related to design aspects of the black cell equipment? What are the current mitigating measures?
3.18 Are any additional margins added to the design of any features in consideration of black cell inaccessibility?

Adequacy of Design Implementation

4.1 Do design documents correctly implement the design requirements for black cells? (Vertical slice review of FRP in PTF)
4.2 How does BNI verify that the requirements and guidance identified in the design process are adequately implemented in the design of the black cell components?
4.3 What technical oversight is provided by BNI engineering management to ensure the adequacy of design products (e.g. model calculations, design calculations, procurement specifications)?
4.4 Have the designs of the large vessels been proven in actual operation at other sites? Has BNI incorporated learning from these previous projects into the design and fabrication of the vessels and piping?

Adequacy of Supplier Implementation

5.1 What types of design models (e.g. vessels, thermal stress, load stress) are used in the BNI suppliers design process? Do these models adequately represent the expected operational conditions (e.g. chemical, thermal, load stress) of the respective black cell process components?
5.2 How are stresses associated with the operation of the fluidic mixing equipment (e.g. pulse jet mixers) accounted for in the design of vessels?
5.3 Explain how the in-process inspections at the vendors shop insures that the spools to be installed in black cells have the correct wall thickness, bend radius, weld details, NDE, and leak testing required in the purchase order.
5.4 Is the BNI inspection program adequately identified in the procurement specifications (here address both BNI oversight and supplier inspections, such as their NDE implementation)?
5.5 What is BNI's QA oversight program for procured components?
5.6 What provisions assure materials used are consistent with design requirements?

Adequacy of Construction Implementation

6.1 Describe the constructability/design reviews that are conducted on large process vessels and piping to ensure that residual stresses are accounted for in the design and eventual fabrication of components?
6.2 Describe the constructability/design reviews conducted to ensure that residual stresses from alignment and final assembly are acceptable.
6.3 How are large vessels handled to ensure the vessels are not stressed during fabrication or in the field during final placement (e.g. design features, rigging requirements, final placement requirements)? Include the lifting and placement of the FRP vessels built by CB&I)
6.4 What tolerances are allowed in piping installation fit up and when is engineering approval required?
6.5 How is the cleanliness of piping components installed in black cells maintained?

Field Inspections to Assure Installation as Designed

7.1 Explain the sequence of inspections, and the controls that are in place for components, which occur from the time components are received on site until they are installed in black cells.
7.2 What are the non-destructive inspection techniques that have been identified for equipment components that will be in the black cells? What is the technical basis for these inspection techniques and inspection frequency?
7.3 What types of acceptance inspections will be made for completed systems to ensure compliance with requirements?
7.4 Explain the characteristics of both automated UT and RT and how they compare for this application in identifying defects that could shorten the life of pipe weld.
7.5 Explain the vacuum box leak test procedure and why vacuum box leak testing is an adequate method of leak testing lines in lieu of pneumatic or hydrostatic testing.

Repeatability for All Black Cells

8.1 What specific requirements and guidance is identified in the BNI design process to ensure adequacy and uniformity in the design of black cell process components? (Address design processes related to procurement support, system design, and physical layout; address organizational structure, work process procedures, and design guidance.)

8.2 What qualification and training program exists for designers of the black cell components?

8.3 What training and qualification is provided to designers who use design models?

8.4 What is the experience level of the designers, and design managers, with respect to qualification to codes and standards, and familiarity with fabrication and construction?

Open Issues

9.1.1 What is the status of the open items associated with the ORP Design Oversight D-03-Design-001, "BNI Materials Selection Process"? (Document provided with ORP Letter 03-WEC-018).

1.2 Schedule of Activities

Table 2 summarizes the schedule for completion of this oversight. BNI will provide initial responses to LOIs at the start of each presentation.

1.4 Documentation

The product of this design oversight will be a management briefing package and a final report that shall contain the sections and content as summarized in Table 3.

The final report shall include any

- Recommendations on methods to improve the activities (e.g. design, fabrication and operational planning) for the process system associated with the black cells.
- Observations from the design oversight. These will be areas of strength and weaknesses in the current BNI identified processes or activities. Favorable aspects of the BNI program will be identified as appropriate.
- Open Items which are work items jointly identified to improve the activities (e.g. design, fabrication and operational planning) associated with the black cells.

The open issues identified in this oversight shall be listed in the final report. Each open issue shall be assigned an item number and shall be tracked to resolution through the CARS for ORP, and RITS for BNI.

1.5 Closure

The Team Leader shall confirm that the open issues from this oversight are adequately resolved.

Table 1 Composition of the Black Cell Design Oversight Team

Function	Personnel/Affiliation	Expertise
Design Oversight Process	Bill Hamel, DOE-Team Leader John Treadwell, DOE-Team Co-Leader Barry Naft, Consultant	Waste Treatment Plant Program Management/Vitrification Operations Design and Construction Management Program Management
Design Oversight Team	Bill Hamel, DOE Jeff Barnes, WSRC Dave Houghton, BNFL Larry Demick, Consultant Tom Ballweg, Bechtel	Waste Treatment Plant Program Management/Vitrification Operations Engineering Management/Plant Startup Construction/Black Cell Design Engineering Management Project Engineering and Design
Construction Oversight Team	John Treadwell, DOE Dave Hooks, Bechtel Tim Adams, Consultant	Design and Construction Management Construction/Piping Design/Welding Vessel & Piping Design/Fabrication/NDE
Operations Oversight Team	Lew Miller, DOE Bill Brasel, Consultant Langdon Holton, PNNL	Nuclear Safety Plant Startup and Operations Process Engineering/Radiochemical Operations

Table 2 Design Oversight Schedule

Activity Description	Responsibility	Complete By
Develop Oversight Plan/Identify Team Members	Hamel	1/15/04
Advise BNI of planned oversight and provide system oversight plan to identify needed BNI support	Hamel	1/15/04
Commence Design Oversight	Team	1/20/04
Design Oversight Discussions with BNI	Team	1/20/04 to 1/23/04
WTP Site Walkdown	Team	1/24/04
Complete Design Oversight Data Collection	Team	1/30/04
Prepare Draft Design Oversight Report	Team	1/29/04
Management Debriefing on Findings and Observations	Team	2/2/04
ORP and BNI review of draft report complete. Open issues identified and reconciled	DOE/BNI	2/2/04
Finalize Design Oversight Report and open issues. Open issues entered into ORP/BNI action tracking systems	Team	2/5/04

Table 3 Contents of Design Oversight Report

- Executive Summary
- Introduction
- Background
  - Objective
  - Scope
  - Approach
- Summary of Results
  - Design Oversight Team
    - LOI Discussion *
  - Construction Oversight Team
    - LOI Discussion *
  - Operations Team
    - LOI Discussion *
- Summary of Recommendations, Observations and Open Items
- References/Bibliography
- Appendices
  - BNI LOI Responses
  - Open Item Issue Resolution

**Address each LOI and resulting-open items and observations.*

Appendix C - ORP Prepared Lines of Inquiry

This appendix is a compilation of the Oversight Team Lines of Inquiry (LOIs). These LOIs were used to provide a structured method to investigate the black cell design processes, construction planning and operations planning information. The LOI's were prepared by the Team members and represent the perspectives of the Oversight Team. Summarized in the Table below are the LOI number, and LOI Question. In some cases the LOS questions have been grouped to avoid duplication in the responses. The LOIs are presented numerically in the appendix.

LOI Number	Lines of Inquiry
1.1	What are the expected operational conditions (e.g. corrosion, erosion, thermal) of the black cell equipment components?
1.2	How has BNI used operational limitations and requirements (including: solids concentration, solids mobilization and transfer, hydrogen mitigation and acid-base reactions) to define design requirements for the black cell vessels?
2.1	How have the following failure mechanisms been characterized and addressed? Are there other significant failure mechanisms that apply to any of the black cell components?
3.1	Are the requirements adequate to meet the WTP contract requirements for design life? Where are they documented?
3.2	What design codes or standards have been selected for the components in black cells and why?
3.3	How is the adequacy of materials of selection for black cell process components determined?
3.4	Are the materials assessments for black cell components adequately bounded based upon requirements and existing data (e.g. materials properties and expected conditions)?
3.5	How were corrosion/erosion allowances determined, including any limitations on fluid velocity, particle size, particle hardness?
3.6	What provisions are made in the piping stress analyses to account for residual stresses due to installation?
3.7	Are specific layout criteria imposed on black cell components to mitigate potential failure mechanisms (such as for piping systems)?
3.8	Are there any provisions or capability for temporary access into the black cells for any purpose?
3.9	What types of design models (e.g. piping, thermal stress, load stress) are used in the BNI design process? Do these models adequately represent the expected operational conditions (e.g. chemical, thermal, load stress) of the respective black cell process components?
3.10	What design models are used for vessel and piping design? What verification has BNI conducted on these models?
3.11	Are there provisions to clear potential pipe or component plugging?
3.12	What level of contingency planning, in terms of identification of equipment redundancy and spares, has been identified in the development of the design?
3.13	Identify the process piping spares that currently exist for each system that is entirely enclosed, or partially enclosed, in a black cell.
3.14	Identify the process piping spares that exist between major facilities (e.g. Pretreatment and HLW Vitrification and Pretreatment and LAW Vitrification).
3.15	Is there an experience base that supports the use of these design concepts with the operational limitations/requirements identified?
3.16	How is BNI documenting operational limitations identified in the materials selection process and design process, and how are these limitations/procedures to be captured in the operational specifications for the facility?
3.17	What are the operational risks that have been identified in the Risk Register that are related to design aspects of the black cell equipment? What are the current mitigating measures?
3.18	Are any additional margins added to the design of any features in consideration of black cell inaccessibility?
4.1	Do design documents correctly implement the design requirements for black cells? (Vertical slice

LOI Number	Lines of Inquiry
	review of FRP in PTF)
4.2	How does BNI verify that the requirements and guidance identified in the design process are adequately implemented in the design of the black cell components?
4.3	What technical oversight is provided by BNI engineering management to ensure the adequacy of design products (e.g. model calculations, design calculations, procurement specifications)?
4.4	Have the designs of the large vessels been proven in actual operation at other sites? Has BNI incorporated learning from these previous projects into the design and fabrication of the vessels and piping?
5.1	What types of design models (e.g. vessels, thermal stress, load stress) are used in the BNI suppliers design process? Do these models adequately represent the expected operational conditions (e.g. chemical, thermal, load stress) of the respective black cell process components?
5.2	How are stresses associated with the operation of the fluidic mixing equipment (e.g. pulse jet mixers) accounted for in the design of vessels?
5.3	Explain how the in-process inspections at the vendors shop insures that the spools to be installed in black cells have the correct wall thickness, bend radius, weld details, NDE, and leak testing required in the purchase order.
5.4	Is the BNI inspection program adequately identified in the procurement specifications (here address both BNI oversight and supplier inspections, such as their NDE implementation)?
5.5	What is BNI's QA oversight program for procured components?
5.6	What provisions assure materials used are consistent with design requirements?
6.1	Describe the constructability/design reviews that are conducted on large process vessels and piping to ensure that residual stresses are accounted for in the design and eventual fabrication of components?
6.2	Describe the constructability/design reviews conducted to ensure that residual stresses from alignment and final assembly are acceptable.
6.3	How are large vessels handled to ensure the vessels are not stressed during fabrication or in the field during final placement (e.g. design features, rigging requirements, final placement requirements)? Include the lifting and placement of the FRP vessels built by CB&I)
6.4	What tolerances are allowed in piping installation fit up and when is engineering approval required?
6.5	How is the cleanliness of piping components installed in black cells maintained?
7.1	Explain the sequence of inspections, and the controls that are in place for components, which occur from the time components are received on site until they are installed in black cells.
7.2	What are the non-destructive inspection techniques that have been identified for equipment components that will be in the black cells? What is the technical basis for these inspection techniques and inspection frequency?
7.3	What types of acceptance inspections will be made for completed systems to ensure compliance with requirements?
7.4	Explain the characteristics of both automated UT and RT and how they compare for this application in identifying defects that could shorten the life of pipe weld.
7.5	Explain the vacuum box leak test procedure and why vacuum box leak testing is an adequate method of leak testing lines in lieu of pneumatic or hydrostatic testing.
8.1	What specific requirements and guidance is identified in the BNI design process to ensure adequacy and uniformity in the design of black cell process components? (Address design processes related to procurement support, system design, and physical layout; address organizational structure, work process procedures, and design guidance.)
8.2	What qualification and training program exists for designers of the black cell components?
8.3	What training and qualification is provided to designers who use design models?
8.4	What is the experience level of the designers, and design managers, with respect to qualification to codes and standards, and familiarity with fabrication and construction?

Attachment to Appendix C
ORP Prepared Lines of Inquiry

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Line of Inquiry

1.1: What are the expected operational conditions (e.g. corrosion, erosion, thermal) of the black cell equipment components?

Discussion of Review:

Based on the limited review of this LOI described below, the reviewers concluded that Bechtel National, Inc. (BNI) partially documented the expected operational conditions of the black cell vessels. These descriptions were partially contained in two types of documents, the material selection data sheets (MSDSs), and corrosion evaluations. Written guidance for the expected description of operational conditions was incomplete, and not available when the descriptions were completed.

The MSDSs were compiled into two references pertinent to the black cells found in the High Level Waste (HLW) facility and the Pretreatment (PT) Facility: *24590-HLW-RPT-PR-02-003, Rev. 0,* Material Selection Datasheets for the HLW Vitrification Facility, and *24590-PTF-RPT-PR-02-002, Rev. A,* Material Selection Datasheets for the Pretreatment Facility.

The only written guidance concerning MSDSs was found in BNI Design Guide *24590-WTP-GPG-M-047, Rev. 0,* Preparation of Corrosion Evaluations, which stated that "the process chemistry conditions will be provided on an MSDS." The reviewers found that this design guide was issued in late 2003. The MSDSs were largely completed in 2001 and 2002. No other written guidance was identified for the preparation of the MSDSs that were used to describe the process chemistry conditions for the black cell vessels. No written procedure or guidance completely implemented the requirement of the Safety Requirements Document, Appendix H, Section 6.0, *Inaccessible Areas* (i.e.; black cells) that, "materials are selected and evaluated to ensure that they are compatible with **the expected operating** conditions [emphasis added] (including temperature, pH, and chemistry) and will last for a design life of 40 years." BNI personnel stated that a design guide for MSDSs was in preparation.

The reviewers found, through discussions with BNI personnel who had prepared the documents, that the HLW MSDSs for the black cell vessels generally provided a summary description of the normal, off-normal, and accident chemical concentrations, radioactivity, and physical properties (such as pH and temperature) expected to be encountered in that vessel. The black cell vessel MSDSs considered in the HLW review were for HOP-VSL-00903/00904 (HLW Submerged Bed Scrubber Condensate Receiver Vessel), RLD-VSL-00002 (Offgas Drains Collection Vessel), RLD-VSL-00008 (HLW Plant Wash and Drains Vessel), RLD-VSL-00007, Acidic Waste Vessel, and HCP-VSL-00001/2 (Concentrate Receipt Vessels). The PT MSDSs for the black cell vessels generally provided only a single set of chemical properties that were the maximum steady state calculated values of chemical properties anticipated based on the contract maximum input values and an associated mass balance calculation *(24590-PTF-M4C-V11T-00001, Rev 1).* All of the PT black cell MSDSs in *24590-PTF-RPT-PR-02-002, Rev. A* were considered in the review. The reviewers noted that expected values of the ranges of normal operating conditions, abnormal, and accident conditions were not identified in the PT MSDSs. The reviewers also noted that none of the MSDSs described the effects of interaction among chemicals on materials, or effects of chemical speciation; the reviewers did not attempt to assess the significance of this omission beyond noting the incompleteness of the specification of operating conditions in this regard.

The MSDS for FRP-VSL-0002A/B/C/D, the PT Waste Feed Receipt Vessels, *24590-PTF-N1D-FRP-00001 Rev 2,* stated that the maximum concentration of undissolved solids was zero. This appears to be in error since a nominal value for the WTP contractual feed is 3.8 wt%. The error is potentially significant, since the concentration of such solids is used by BNI to assign an erosion allowance to be included in the corrosion allowance. Calculation *24590-WTP-MOC-50-00004 Rev B*, Wear Allowance for Waste Slurry Systems, Section 7.1.2.1, describes that for solids concentrations less than 2 %, no erosion allowance is assigned. The reviewers did not determine whether correction of this error would have affected material selection. The reviewers later found BNI made the assumption that the solids dissolved as a means to add conservatism to the corrosion assessment.

Finally, one inconsistency was noted between the concentration components listed in the MSDS for CNP-BRKPT-00002, Cs Evaporator Breakpot and in the MSDS attached to the corrosion evaluation for this vessel. Specifically, the MSDS values for sulfate and carbonate were significantly different, between the MSDS in *24590-PTF-RPT-PR-02-002, Rev. A* and the corrosion evaluation for the Cs Evaporator Breakpot, 24590-PTF-N1D-CNP-00008. The effect of this error on material selection was not assessed due to the limitations of the review.

Corrosion evaluations were prepared by BNI to "document the thought process in determining types of materials and minimum corrosion allowances that should be used in the design of process vessel and piping, " according to BNI Design Guide *24590-WTP-GPG-M-047, Rev. 0*, Preparation of Corrosion Evaluations, which was approved on November 9, 2003. The reviewers found that the design guide required that the evaluation identify the environment the material would be subjected to, and the types of corrosion that the material would be subjected to. The design guide otherwise provided little guidance concerning how to perform a corrosion evaluation. BNI personnel stated that this design guide reflected how corrosion evaluations were performed prior to issuance of the design guide. The MSDSs attached to the corrosion evaluations for FRP-VSL-00002A/D (PTF) Waste Feed Receipt Vessels (24590-PTF-N1D-FRP-00001, Rev 2, CNP-BRKPT-00002 (PTF), Cs Evaporator Breakpot, 24590-PTF-N1D-CNP-00008, and HCP-VSL-00001/2 (HLW), HLW Concentrate Receipt Vessel were reviewed. All had been approved in 2002. All evaluations reviewed contained a recommendation of the material to be used, and from the "corrosion considerations" conclusion selection, the reviewers could infer the types of corrosion that were used as a basis for the selection of the material. MSDSs for the respective vessel were attached to the corrosion evaluations.

There was insufficient information in the evaluations reviewed to determine why the selections had been made. This was partially due to the incomplete nature of the PT MSDSs described above, and partially due to the limited and sometimes contradictory exposition found in the evaluations. For example, in the Cs Evaporator Breakpot discussion of stress corrosion cracking, for which the design temperature is given as 352 degrees F, the evaluation states:

> *"The exact amount of chloride required to stress corrosion crack stainless steel is unknown. . . Hence, even as little as a few ppm can lead to cracking under some conditions. . . The use of 304L [stainless steel] is acceptable."*

However, the attached MSDS states that the calculated value of chloride is 8.6E-03 g/l (approximately 8.6 ppm), and fluoride is 1.1E-02 g/l (approximately 11 ppm). The basis for the conclusion that the effect of these halide components on 304 L material was not considered significant was not provided.

Results, Conclusions and Recommendations:

Recommendations

1. See Recommendation in LOIs 3.3/3.4

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Observations

None

Open Items

1. BNI should update the MSDS for FRP-VSL-0002A/B/C/D, the PT Waste Feed Receipt Vessels, *24590-PTF-N1D-FRP-00001 Rev 2*, to have a minimum solids concentration consistent with the WTP contract value of 3.8 wt%.

BNI personnel contacted in this review:

Name	Organization	Title
Dale Obenauer	BNI	Discipline Manager, Process Engineering

References:

1. 24590-WTP-GPG-M-047, Rev. 0, Preparation of Corrosion Evaluations,
2. 24590-WTP-RPT-M-01-001, Rev 0, "Material Selection Guide" May 19, 2003.
3. 24590-WTP-GPG-M-047, Rev 0, "Mechanical Systems Design Guide: Preparation of Corrosion Evaluations" November 9, 2003.
4. 24590-WTP-M06-50-00004, Rev B, "Wear Allowances for WTP Waste Slurry Systems" October 20, 2003.
5. 24590-HLW-RPT-PR-02-003, Rev. 0, Material Selection Datasheets for the HLW Vitrification Facility
6. 24590-PTF-RPT-PR-02-002, Rev. A, Material Selection Datasheets for the Pretreatment Facility.

Prepared by: Lew Miller, Langdon Holton

Review and Approval (sign and date):

John Treadwell	William Hamel	Barry Naft

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Line of Inquiry

1.2: ***How has BNI used operational limitations and requirements (including: solids concentration, solids mobilization and transfer, hydrogen mitigation and acid-base reactions) to define design requirements for the black cell vessels?***

- ***Process Composition***
- ***Static Loads***
- ***Dynamic Loads***
- ***Thermal Loads***
- ***Environmental Controls***
- ***Construction Stresses***

Discussion of Review:

LOI 1.1 describes how BNI determined the operational conditions of the black cell equipment components, as it relates to the evaluation of corrosion. LOI 3.5 describes how BNI determines the expected erosion of the black cell equipment components (especially piping), including consideration of the effect of glass formers. Those discussions are not repeated here. Also, BNI has not yet completed defining how non-Newtonian fluid solids mobilization and transfer concerns, or hydrogen mitigation considerations should affect the design of the components which have significant solids or hydrogen evolution potential as part of their constituents.

The reviewers noted from discussions with BNI personnel that black cell equipment components were designed, and were being designed, on a system-by-system basis. Other than the specification of a 40 year life for such components and requiring a 100% volumetric examination of the primary containment weld, BNI personnel could not identify a specific review of the black cell equipment that had been performed on a black cell by black cell basis. The design requirements documentation (Basis of Design, Operations Requirements Document) does not provide any unique requirements for equipment components located in black cells. BNI personnel had not identified those components within the black cells whose failure would significantly impact plant operations. Although some spare components for the main process flow paths had been identified, a comprehensive list of these had not been prepared. During the review, some spares were identified, as features of particular system designs. Beyond the 40 year life criterion, BNI had not pre-established criteria for spare components and flow paths in the black cells. The reviewers concluded that, absent such criteria, the potential existed (with unknown probability), that operation of the facility would be significantly impacted by unexpected component malfunctions. These malfunctions could be caused by corrosion, erosion, or blockage due to deposits, greater than assumed by the designer. Given the uncertainties and unverified assumptions inherent in determining component life in the all WTP process and support system environment, this absence of criteria and an associated black cell design review, appeared to be a potentially significant oversight.

Other design requirements arising from operational limitations and requirements such as vessel and piping design loadings were defined using the design codes defined in the Safety Requirements Document Safety Criteria (SC), principally SC 4.2-2. These codes include ASME B31.3-96, *Process Piping*, and ASME Section VIII, *Boiler and Pressure Vessel Code, Rules for Construction of Pressure Vessels*. The reviewers concluded that these requirements were being implemented, based their limited review.

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Results, Conclusions and Recommendations:

Recommendations

None

Observations

None

Open Items

None

BNI personnel contacted in this review:

Name	Organization	Title
Steve Vail	BNI	Mechanical Systems Materials and Compliance Supervisor

References:

1. 24590-WTP-RPT-OP-01-001, Rev 2, "Operations Requirements Document", May 5, 2003.
2. 24590-WTP-DB-ENG-01-001, Rev 1A, "Basis of Design", November 23, 2003.

Prepared by: Lew Miller, Langdon Holton, Bill Brasel

Review and Approval (sign and date):

John Treadwell	William Hamel	Barry Naft

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Line of Inquiry

2.1: *How have the following failure mechanisms been characterized and addressed? Are there other significant failure mechanisms that apply to any of the black cell components?*

- *Corrosion*
- *Erosion*
- *Fatigue/Cyclic Loadings*
- *Overstress due to Normal or Occasional Loads*
- *Residual Stress*
- *Plugging*
- *Design/Fabrication/Installation errors*

Discussion of Review:

The reviewers have concluded that BNI had acceptably characterized and addressed the listed failure mechanisms, except as noted previously in the ORP response to LOIs 1.1, 1.2, and 3.5. The reviewers recommend that BNI define and include specific additional design, installation, and construction reviews for mission critical black cell components to ensure that their design, fabrication and construction were adequate. Mission critical components are those that are essential to allow the WTP facilities to continue to operate at or near the design capacity.

The reviewers found that BNI characterized a spectrum of corrosion failure mechanisms in 24590-WTP-RPT-M-01-001, Materials Selection Report, and described erosion failure mechanisms in 24590-WTP-M0C-50-00004, Rev B, Wear Allowances for WTP Waste Slurry Systems. The reviewer's evaluation of BNI's dispositions of these failure mechanisms is described in LOI 1.1, 1.2, and 3.5, and will not be repeated here.

As described in LOI 3.11, the reviewers found that BNI has given the requirement to provide provisions for the unplugging of piping and devices adequate consideration in the design process.

The reviewers also found from presentations by BNI personnel, that BNI considered the design codes and standards for the WTP adequately characterized failure mechanisms such as fatigue/cyclic loadings, overstress due to normal or occasional loads. Specifically, the codes and standards that address these topics are ASME Section VIII and ASME B 31.3, Process Piping. After consideration of these presentations, the reviewers agreed that the design codes and standards provisions were adequate to prevent failure of black cell components due to these mechanisms.

BNI personnel considered that the combination of low stress in vessels, control of construction piping alignment (including procedural limits on cold springing), and the use of ductile materials were sufficient to ensure that residual stress did not contribute significantly to the probability of piping or vessel failure. The reviewers agree with this judgment.

BNI personnel described the design control process as consisting of design procedures and guides, trained and qualified personnel, and careful review by multiple engineering personnel. The reviewers concluded, based on this description, that proper execution of the established design processes and use of the approved design requirements would ensure an adequate design. Similarly, fabrication and installation errors would be prevented by the detailed quality control and assurance program, including the system for identification and correction of errors, if these programs were properly executed.

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Summary of Results in Review of Lines of Inquiry (LOI)

However, given the difficulty of preventing all significant human errors, the reviewers concluded that failure of black cell components due to design, fabrication or installation errors could not always be prevented by the controls in effect. The reviewers observed that some errors in design and construction had been identified, but the combination of BNI and DOE oversight had been sufficient, to date, to identify and correct these errors. The reviewers noted that while human error could never be eliminated, the consequences of human error could be reduced to acceptable levels.

Results, Conclusions and Recommendations:

Recommendations

None

Observations

1. BNI has ensured that residual stress does not contribute significantly to the probability of piping or vessel failure in their design and fabrication processes.

Open Items

None

BNI personnel contacted in this review:

Name	Organization	Title
Dale Obenauer	BNI	Process Engineering Supervisor-Central Engineering

References:

1. 24590-WTP-RPT-M-01-001, Rev 0, "Material Selection Report" May 19, 2003.
2. 24590-WTP-GPG-M-047, Rev 0, "Mechanical Systems Design Guide: Preparation of Corrosion Evaluations" November 9, 2003.
3. 24590-WTP-M06-50-00004, Rev B, "Wear Allowances for WTP Waste Slurry Systems" October 20, 2003.

Prepared by: Lew Miller, Langdon Holton

Review and Approval (sign and date):

John Treadwell	William Hamel	Barry Naft

DOE ORP Black Cell Design Review Oversight
Summary of Results in Review of Lines of Inquiry (LOI)

Line of Inquiry:

3.1: *Are the requirements adequate to meet the WTP contract requirements for design life? Where are they documented?*

3.2: *What design codes or standards have been selected for the components in black cells and why?*

Discussion of Review:
The requirements unique to black cells are contained in Section 6 of Appendix H of 24590-WTP-SRD-ESH-01-001, Rev 3b, Safety Requirements Document, Volume II as follow:
Correct Material Selection, Adequate Corrosion Allowance, High Quality Assurance Requirements, Vessel Design, Piping Design, Redundant Components – where appropriate, Flushing Provisions, Fatigue Analyses, Traceability of Materials, Control of Welding Processes, Positive Material Identification, Volumetric Inspection, Hydrostatic and Pneumatic Tests, Cold Chemical Testing, and Monitoring of Process Operating Conditions .

Two basic design codes chosen for the design of vessels and piping in the black cells are ASME Section VIII and ASME B31.3-1996, respectively. The year of ASME Section VIII for the vessels varies because the ASME Code inspector is required to use the applicable code in effect at the time of the purchase of the vessel. On the other hand, the 1996 edition of ASME 31.3 was chosen so that the stress analysis was consistent with the stress analyses approved by the NRC. It is important to fix the date of the piping code early since a number of downstream design decisions and procurement depend on the code edition. The ASME Section VIII and ASME B31.3 are the same design codes that were chosen for the PC-3 process piping, and are the same codes specified in DOE G 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide, for Safety Significant and Safety Class vessels and piping to provide primary confinement and prevent or mitigate radioactive and/or hazardous material releases to the environment. ASME B31.3 is used for piping typically found in petroleum refineries, chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants, and related processing plants and terminals. The WTP Project is a chemical plant processing radioactive and hazardous waste. By letter on November 19, 1993, the following interpretation (12-20) was obtained from the ASME:

Question: In accordance with ASME B31-1993 Edition, may the owner apply B31.3 to piping containing radioactive fluids in a chemical plant.

Reply: Yes, see the Introduction which states that, "If no section of the code for pressure piping specifically covers the installation, the owner at his discretion may select any section determined to be generally applicable... It should be noted, however, that requirements supplementing the Code Section may be necessary to provide safe piping for the intended application."

For the black cells, the WTP Project has determined that the additional requirements in Section 6 of Appendix H of the SRD will augment the requirements of ASME B31.3. The 1996 edition of the ASME B31.3 was chosen so that it was consistent with the stress analyses approved by the NRC. In Regulatory Guide 1.143, Revision 2, Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants, the NRC approved the use of ASME B31.3, for piping and valves, and ASME Section VIII, for pressure vessels. In some cases, ASME Section III provides more design details than does ASME Section VIII or ASME B31.3. As allowed by ASME B31.3, the WTP project has adopted some of the methodology used in ASME Section III, where details are not provided in ASME B31.3.

HVAC Design codes for ventilation of Black Cell are ASME AG-1-97 with ASME AG-1a-2000 addenda, Code on Nuclear Air and Gas Treatment, SMACNA Rectangular Industrial Duct Construction, 1st edition, 1980 and SMACNA Round Industrial Duct Construction, 2nd edition, 1999. Ref: [System Description for PTF C5 Ventilation System C5V, 24590-PTB-3YD-C5V-00001, Rev B]. These are appropriate choices

Results, Conclusions and Recommendations:

The rationale for selection of ASME Section VIII and ASME B31.3-1996 is reasonable and appropriate.

A good practice observed includes detailing of Feed Receipt Vessels FRP-VSL-00002A/B/C/D nozzle internals so that fluids entering the tank extend inside the vessel to assure that chemical additions drop freely into the vessel rather than dribble along the vessel wall. This reduces the risk that concentrated chemicals added to the vessel will attack the vessel locally. Vessels are qualified to Seismic Category 1 levels. BNI should ensure that Black Cell Vessels have this feature.

WTP Project has elected to qualify all QL-2, SC-II piping and supports located in black cells as Seismic Category I. This good practice significantly simplifies control and management of potential seismic interaction.

Black Cell Requirements reflected in design documents

Black cell boundaries for piping systems are defined on some P&IDs. Sometimes the transition to black cell is labeled C5 which could be either black cell or hot cell. Examples are Plant Wash P&IDs PTF-M6-FRP-00009 & 10 Rev 1.and 24590-PTF-M6-PVP-00020 Rev 1, P&ID-PTF Pretreatment Vessel Vent Process System Passive Purge Air Inlet System. BNI should establish design process "rules" for consistently and explicitly identifying black cell boundaries on primary drawings and documents (e.g. P&IDs, V&IDs, GA).

Propagating black cell boundary information from primary drawings to down stream physical drawings (e.g. isometrics) or data bases (e.g. Line list, equipment) is done indirectly. Black cells contain QL-1, SC-I and QL-2, SC-II and CM, SC-III components. The fabrication isometrics for the QL-2, SC-II lines located in the black cells still shows these lines to be QL-2, SC-II. The Line List also shows these lines as SDC and SC-II even though the lines are qualified as SC-I. There is great potential for the downstream users (fabricators, construction, QC) of these documents to miss the fact that this line IS subject to the black cell requirements. BNI should establish "rules" to consistently and explicitly identifying black cell requirements on physical fabrication and construction drawings, and collateral databases. [3.2]

Recently BNI wrote a CAR to address the programmatic implications of an NCR regarding the lack of 100% volumetric examination of black cell vessel SBS Condensate Receiver Vessel (HOP-VSL-00903). It is understood that the path forward is expected to be either a specification or vessel data sheets revision.

The C5V HVAC system components located inside the black cells will be inaccessible. No requirements could be identified for C5V ventilation system in black cells. [Ref: 24590-PTF C5V 00001, Rev B, System Description for PTF C5 Ventilation System, C5V and 24590-WTP-DB-ENG-01-001 Rev 1, Basis of design, Section 12 – Ventilation Basis of Design]. BNI should determine and document the requirements (e.g. SC-I, support, inspection requirements, NDE requirements) for any black cell HVAC systems and components located in black cells.

The isometrics, sheets 388, 390 and 392 of in-process stress calculation 24590-PTF-P6C-FRP-50001 Rev A include both black cell piping as well as piping outside the black cells. Construction work area 50 identified on these isometrics; yet the black cell piping is in construction work area 01. BNI should evaluate the acceptability of the computer generated isometrics to identify the correct construction work area when a pipe crosses a construction work area boundary. BNI should verify that any design issued for fabrication contains the correct construction work area and the scope of black cell piping.

Isometrics, sheets 346 and 347of in-process stress calculation 24590-PTF-P6C-FRP-50001 Rev A both have black cell piping designs which have pockets that do not drain. BNI should verify that the design issued for fabrication drain if required by the process.

<u>HVAC Dampers located in Black Cells</u>
HVAC C5 Hot cell exhaust is drawn into the north Black Cells. Volume dampers used to balance the C5 exhaust system are located inside the north black cells. The current approach is to perform the air balance during and some time before hot commissioning, permanently fix [weld] the adjustable volume dampers before the Black Cell is sealed. This precludes the rebalance or adjustment of the C5 HVAC balance during operation. Adjustment for future operational flexibility to accommodate variation in process feed streams and processing merit consideration. [24590-PTF-P2-P63T-00102 Rev 0, and 24590-PTF-P2-P63T-00101, 106, 107, 111, 112 all Rev 0]. BNI should consider relocating the volume dampers to a place where they can be physically adjusted in the future by some means or devising volume dampers that can be adjusted from the hot cell side. [3.2]

<u>Pretreatment Vessel Vent Process System</u>
The supply air to the black cells is via "in-bleeds" from a C2/C3 area. A portion of this air is metered and drawn through the Pretreatment Vessel Vent Process System [24590-PTF-M6-PVP-00020 Rev 1]. The PVP system will interact with the Vessel Overflow System (PWD). Maintaining an acceptable air flow balance among the PVP system and the vessel overflow system (PWD) may be very difficult. It seems likely that potential "short circuits" exist that could impair the operation of the overflow system or result in more or less sweep air through a given vessel than needed. It appears that this cannot be adjusted from outside the black cells should the systems not balance. The hydraulic calculation sizing the FRP vessel overflow gravity drain lines to their final destination should factor in any significant air flow that may occur. There are no means of balancing or adjusting PVP / PWD system interaction from inside the black cells. BNI should evaluate the air flow balance interaction of the Pretreatment Vessel Vent Process PVP system with the vessel overflow system (PWD).

Given the complex interaction of the PVP and PWD systems BNI should evaluate the overpressure / vacuum protection for the FRP system including system operational scenarios and equipment failure scenarios to determine the limiting design case. The evaluation should describe how limiting cases were factored into establishing the vacuum design pressure for the FRP vessels, large diameter piping and other devices connected to the vessel vent header and system.

<u>Socket Welds and Filet Welds on Black Cell Piping.</u>
Pipe fabrication specification allows PT/MT on socket welds, branch connections and attachment welds (e.g. branch connection reinforcements and pipe support lugs) for black cell pipe (App A , 24590-WTP-3PS-PS02-T0001 Rev 3) This infers that socket welds, fillet welds, etc. are permissible configurations for black cell piping. These geometries are incompatible with the requirement to perform 100% Volumetric examination (UT or RT) as required by Section 6 of Appendix H of 24590-WTP-SRD-ESH-01-001, Safety Requirements Document, Volume II. [Same comment applies to 24590-WTP-3PS-PS02-T-00003 Rev 1, App A.] For example, weldolets are specified as branch connections on 24590-PTF-P3-PJV-GV00023001 Rev A which is sheet 342 of in-process calculation 24590-PTF-P6C-FRP-50001 Rev A. Based on the SRD Appendix H volumetric examination of welded attachments (e.g. pipe support lugs) to black cell piping would also be expected. ASME B31.3 usually required hydrostatic or pneumatic testing after welded attachments are made to piping. Consideration should be given to vacuum box testing of such attachments if done after code pressure testing. BNI should evaluate the permissible

configurations for black cell piping related to socket welds, branch connections, welded reinforcement pads and other welded attachments to piping. BNI should evaluate the required nondestructive examination for the permissible configurations. BNI should update Appendix A regarding inspection requirement for black cell piping as appropriate. [3.2]

Pipe Slope Verification
As written, the dimensional tolerances provided for piping erection and support installation could result in slope reversal from that being specified while being in tolerance. Slope is specified for process piping for process reasons. Specific slope installation and verification criteria are not provided in the specification. Slope verification should be a top level inspection criteria for piping above all other tolerances not withstanding piping erection / installation. BNI should evaluate the adequacy of the 24590-WTP-3PS-PS02-T-00003 Rev 1, Section 3.6.6, regarding pipe slope and slope verification for process lines.

Black Cell Piping Design Pressure
BNI should identify the design pressures basis for lines that may be used for unplugging fluidics components or other components than may become plugged. If other lines may potentially be used to recover from off normal events, this should be identified and considered in establishing the design pressure.

Robustness of Break pots
Based on the presentations, the break pots located in several black cells appear to have demister, bubble tray like sections within them. Typically these are relatively fragile and susceptible to damage from fluid transients and deposits of soluble and insoluble solids. BNI should identify what provisions have been incorporated into break pot design and the design of other internals to make them sufficiently robust to assure a forty year service life. The evaluation should address fluid flashing, impingement or other transients that have been considered in the design of these vessels and internals.

Seismic Category III Items in Black Cells
BNI to advise what provisions are being made to preclude seismic interaction of three vessel applications (TCP-1, TLP-A&B and CNP-4) were identified as SC-III items with SC-I items in the black cells. If these vessels do indeed remain SC-III, it may be difficult to seismically qualify the piping connected to them as SC-I. [3.2]

Carbon Steel Pipe Support Materials for Stainless Steel Piping
BNI should provide the engineering rationale for placing stainless steel pipe directly in contact with painted carbon steel support steel (w/o SS shims), using carbon steel bolts, carbon steel U-bolts, within black cells especially at lower levels which may be wetted by the cell wash/spray system or potentially rinsed with nitric acid solution for decontamination. [Reference requirement of 24590-WTP-GPG-ENG-005 Rev 1 item 10, page 42 of 163.]

Consideration should be given to selection of coatings used in the black cell recognizing that structural carbon steel, structural fasteners and concrete are attacked by nitric acid. [3.2]

Securing Mechanical fasteners in Black Cells
BNI should evaluate the method of installing tightening and securing pipe support bolts, u-bolts and other mechanical fasteners to ensure they will remain secure for the forty year service life of the facility. [3.2]

Conflicting Data on Rate of Erosion based on Impingement Angle
BNI should evaluate the erosion wear allowance for vessels with PJMs accounts for the higher wear rate of stainless steel when the surface to particle angle is small, [e.g. ~<30 degrees] such as observed during site inspection of the perimeter PJMs in FRP-VSL-00002A/B/C/D. This should be evaluated for all other