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

AUG 2 5 2006

06-WTP-109

Mr. C. M. Albert, Project Manager
Bechtel National, Inc.
2435 Stevens Center Place
Richland, Washington 99354

Dear Mr. Albert:

CONTRACT NO. DE-AC27-01RV14136 - TRANSMITTAL OF U. S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT: "HYDROGEN IN PIPING AND ANCILLARY VESSELS (HPAV) GENERIC SOLUTIONS" (D-06-DESIGN-023)

ORP conducted a design oversight of the Bechtel National, Inc. (BNI) generic solutions for the accumulation and potential detonation of hydrogen in Waste Treatment and Immobilization Plant (WTP) piping and ancillary vessels and is transmitting the resulting report by attachment to this letter. The oversight was performed in accordance with the subject Contract (Section C, Clause C.3 and Standard 3). The conclusion of the oversight is that, while BNI has made substantial progress in the design of the HPAV generic solutions, significant work remains to implement these solutions into the physical plant and project programs and evaluate the impact of these solutions on plant availability. The Open Items identified in the attached report reflect design and programmatic attributes that BNI must consider in the final design and implementation of the HPAV generic solutions and provide ORP with a documented basis for closure. BNI is requested to input these Open Items into their Recommendations and Issues Tracking System and to keep them open until closure notification is received from ORP. Within 30 days of receipt of this report, BNI is requested to provide ORP with a plan and proposed schedule for the response to these Open Items.

The technical direction herein is considered to be within the limitations of Contract Clause H.1 "Technical Direction" and does not meet any of the conditions described in paragraph (b)(1) through (4) of the clause. In the event the Contractor disagrees with this interpretation, it shall not proceed but shall notify the Contracting Officer immediately orally and in writing within five working days in accordance with the Contract (Section H, Clause H.1 "Technical Direction").

If you have any questions, please contact me, or your staff may call Lewis F. Miller, Jr., Acting Director, WTP Engineering Division, (509) 376-6817.

Sincerely,

John R. Eschenberg, Project Manager
Waste Treatment and Immobilization Plant Project

WED:RWG

Attachment

cc w/attach:
W. S. Elkins, BNI
BNI Correspondence

ATTACHMENT

HYDROGEN IN PIPING AND ANCILLARY VESSELS (HPAV) GENERIC SOLUTIONS DESIGN OVERSIGHT REPORT D-06-DESIGN-023

06-WTP-109

HYDROGEN IN PIPING AND ANCILLARY VESSELS GENERIC SOLUTIONS DESIGN OVERSIGHT REPORT D-06-DESIGN-023

August 2006

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8/16/06

Lewis F. Miller, Jr., Acting Director,
WTP Engineering Division

EXECUTIVE SUMMARY

The U.S. Department of Energy, Office of River Protection Waste Treatment and Immobilization Plant (WTP) Engineering Division performed a Design Oversight of Bechtel National, Inc. (BNI) proposed generic solutions for hydrogen accumulation and explosion in WTP piping and ancillary vessels.

The objectives of this Design Oversight were as follows:

- Determine the technical acceptability, viability, and effectiveness of the proposed hydrogen in piping and ancillary vessels (HPAV) generic solutions.
- Identify any impacts to the WTP flowsheet, throughput, risk register, safety/authorization basis, or total operating efficiency.
- Determine if proposed operational requirements/expectations are consistent with equipment access, staffing, coincidental operating requirements, etc.
- Determine if proposed HPAV generic design solutions are adequately supported by research and technology program results.

The Design Oversight Team concluded the BNI approach and effort in addressing the HPAV issue were comprehensive and thorough (based on the information reviewed and discussions with cognizant personnel during the course of the assessment). While not specifically evaluated during this Design Oversight and the subject of other ORP reviews in progress, it appeared to the team that the BNI efforts to analyze the potential for hydrogen accumulation (whether from gases generated from waste streams or from radiolysis of water streams) were conservative and bounding for conditions expected in WTP. It also appeared to the team that the full range of potential sites for detonations of the accumulated hydrogen had been identified and evaluated in the areas of significant concern; namely, the Pretreatment Facility (PTF) and High-Level Waste (HLW) Facility.

The BNI evaluations of the potential for hydrogen explosions identified measures that are required to maintain the plant in a safe condition (i.e., protect the health and safety of the public, co-located worker and facility worker). These measures focus on ensuring the integrity of the first line of containment in the event of an explosion (i.e., piping and vessels), either by providing design features or important-to-safety (ITS) engineered features to prevent the accumulation of hydrogen, or by confirming the integrity of the components under postulated worst-case explosion conditions. BNI also identified additional actions to be taken to minimize the impact of potential hydrogen explosions on the availability of affected systems and components. These actions are intended to minimize the potential for the accumulation of hydrogen to explosive levels (e.g., by ensuring that stagnant waste streams are flushed before significant levels of hydrogen accumulate).

However, the Design Oversight Team concluded that the BNI work on addressing HPAV was not complete. For example, BNI had not completed development and reconciliation of the safety case and availability piping matrices, completed design and application of engineered features to the plant, or completed the assessment of HPAV impacts on PTF and HLW availability. In addition, there were several open items from the BNI External Guidance and Review Team reviews that were not resolved. These open items paralleled some of the areas that were reviewed and determined to be open during this assessment. The following are specific areas identified by the Design Oversight Team that must be considered by BNI as they complete their work on HPAV.

1. Use of a block and bleed configuration instead of a double isolation valve design for isolation between WTP waste-containing systems and interfacing utility systems to allow venting the cross-connect between the isolation valves and prevent leakage through either valve from entering the interfacing system.
2. Applicability of the current calculated frequency, number of cycles, and timing of cycles for a full pulse jet mixer (PJM) for the case of a PJM that is not full.
3. Impact that post-design basis event (DBE) operation of the three ITS air compressors will have on the loading of the facility emergency diesel generators, accounting for HPAV-related air loads in addition to those required for other post-DBE functions.
4. Technical basis for concluding that the HPAV generic solution involving the addition of high point vents on pump suctions will operate properly following a DBE that results in Pretreatment Vessel Vent Process System (PVP) pressurization/loss of vacuum.
5. Evaluation of the quantities of water required to perform line flushes, as part of the HPAV generic solutions, and the basis for concluding that flowsheet impacts due to this additional water have been optimized and are acceptable.
6. Evaluation of the additional effects attendant to a hydrogen deflagration or detonation (e.g., the potential for oscillatory loads to be imposed on WTP piping if the fluid boundaries are not incompressible, the impact of the high-speed ejection of a waste slug or bubble from connected piping into PTF and HLW vessels, and the potential for and consequences of a post-detonation water hammer event as the affected piping refills.)
7. Impact of temperature spikes that occur during postulated hydrogen detonations in WTP piping and ancillary vessels on the post-detonation functionality of affected components (e.g., pumps, valves, instruments, seals, gaskets) and the impact of the repair or replacement of these components on plant availability.
8. Evaluation of the fail open design of the purge air isolation valves in the air racks supplying the Ultrafiltration Process System (UFP) pump suction line to determine if the potential impact to plant availability could be reduced through the use of a fail close valve design.
9. Evaluation of the need for redundancy in the purge air system to the high pressure side of the UFP system (i.e., the air purge for the UFP piping, heat exchangers, filters, and pump).
10. Revision of the formal Configuration Management Program to account for HPAV items.

The Design Oversight Team reviewed the results of this oversight with BNI staff during the period June 5 – 15, 2006.

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) will design, construct, commission, and operate a Waste Treatment and Immobilization Plant (WTP) to treat and immobilize waste contained in 149 single-shell tanks and 28 double-shell tanks (DST) at Hanford. These tanks contain approximately 54 Mgal waste with 190 MCi radioactivity. The WTP will receive waste in batches from the DSTs through transfer pipelines. This waste will be concentrated in an evaporator; strontium and transuranic will be precipitated from select waste streams; solids will be water washed, caustic leached, oxidative leached, and separated from the soluble fraction in an ultrafilter system; and cesium will be removed from the soluble fraction with an ion exchange system. The radionuclide rich solids and cesium ion exchange eluant will be combined and immobilized in high-level waste (HLW) glass. The low-activity waste (LAW) supernatant will be further concentrated and immobilized in LAW glass or immobilized in an alternative waste form currently being studied.

Several processes take place in the high- and low-level liquid radioactive waste received from the Hanford Site tank farms that produce hydrogen and other gases. The hydrogen production processes include radiolytic decomposition of water, and radiolytic and thermolytic decomposition of organic components in the waste. The gases produced by these processes can evolve continuously or they can be retained in the waste and be released suddenly. In either case, hydrogen could accumulate in selected process equipment and piping if not removed.

This Design Oversight Report documents the ORP WTP Engineering Division (WED) evaluation of the generic solutions identified by Bechtel National, Inc. (BNI) to address the potential for the accumulation and explosion of hydrogen in WTP piping and ancillary vessels (referred to as hydrogen in piping and ancillary vessels [HPAV]). ORP's Design Product Oversight Plan for the BNI HPAV generic solutions is provided in Appendix C. Note: The dates in the oversight schedule included in the attached Oversight Plan are not correct because the original schedule for the oversight was changed (delayed) at the request of BNI.

2.0 BACKGROUND

The prevention and mitigation of the potential hazards associated with hydrogen accumulation in WTP process vessels was addressed in the project's original design work and uses large volumetric flow purges and mixing design features for hydrogen control. The accumulation of HPAV was recognized as a potential hazard in April 2002 with the issuance of U.S. Nuclear Regulatory Commission Information Notice 2002-15, "Hydrogen Combustion Events in Foreign BWR Piping" (Reference 1). Subsequently, ORP issued a Preliminary Safety Analysis Report (PSAR) Condition of Acceptance (CoA), as follows: "By December 31, 2005, the Contractor must evaluate the potential for piping systems and ancillary equipment to accumulate hydrogen and the potential control strategies. The potential for piping systems and ancillary equipment to accumulate hydrogen must be incorporated into the DBE calculations and the PSAR as applicable."

The ancillary vessels in which hydrogen has the potential to accumulate include the pulse jet mixers (PJM) and small vessels such as reverse flow diverter (RFD) charge vessels. The accumulation of hydrogen and oxidant must either be prevented, or controlled and evaluated to show that the resulting challenges to process systems and vessels and important-to-safety (ITS) systems are acceptable.

In response to the ORP PSAR CoA, BNI evaluated the WTP locations where hydrogen and oxidant can accumulate in stagnant regions of process and auxiliary piping and ancillary vessels when waste containing systems stop flowing due to normal process evolutions or abnormal events (e.g., branched lines or dead legs, equipment failure, maintenance evolutions, or as the result of a design basis event [DBE]). Using their Integrated Safety Management (ISM) process, BNI conducted a comprehensive evaluation of all fluid systems in the WTP (involving approximately 18,000 pipes in the Pretreatment Facility [PTF] and HLW Facility, and the connecting Balance of Facilities [BOF] piping) where hydrogen could be generated as a result of the radiolytic decomposition of water, radiolytic decomposition of organics, or the thermal decomposition of organics. Systems with no potential hydrogen issues (i.e., systems that do not contact the waste and do not contain water/reagents exposed to high radiation) were identified and excluded from further analysis.

The hydrogen accumulations in WTP ancillary vessels and piping systems were initially evaluated by BNI using the criteria documented in 24590-WTP-SE-ENS-04-0197 (Reference 2) and 24590-WTP-SE-ENS-05-0076 (Reference 3), with the criteria revised to prevent any hydrogen explosion that could lead to fragmentation due to failure of an ancillary vessel or piping system. The BNI HPAV evaluations were re-performed, as necessary, to incorporate direction from ORP (Reference 4). The ORP direction essentially limited the loading due to HPAV detonations in piping and ancillary vessels to the material elastic limits or, in exceptional cases supported by risk assessment, allowed limited plastic behavior.

The evaluation criteria used by BNI (and undergoing review by DOE; thus, subject to modification) were as follows:

- If the time to a hazardous condition was more than 1,000 hours, no additional ITS protective features beyond normal plant services were required.
- A hazardous condition for open systems was defined as an inventory of hydrogen in a concentration greater than 8% by volume. Open systems are those with a free surface during normal operation (e.g., PJM, RFD charge vessel). The HPAV hazard in open systems is addressed by limiting the maximum allowed concentration of hydrogen in the volume above the free surface. Note: In all instances, controls were implemented to limit the concentrations of hydrogen to 1 vol % during normal operations and 4 vol % post-DBE.
- A hazardous condition for closed systems was defined as an inventory of hydrogen exceeding a "bubble of concern" (BOC). Closed systems do not have a free surface during normal operation (e.g., piping). The HPAV hazard in closed systems is addressed by limiting the inventory of hydrogen available for combustion. A BOC is the volume of hydrogen that, if exploded, results in a response that exceeds the WTP acceptance criteria for the pipe. The acceptance criteria used by BNI for the safety case was based on preventing unacceptable exposures to workers and the public and, for the availability case, operational or non-routine events were not to accumulate hydrogen to volumes that, assuming detonation, challenge piping, jumper, or in-line equipment/instrumentation operability. Process and utility piping with hydrogen generation potential were treated as closed systems.
- Engineered protective features were provided for events with high consequences (Severity Level 1, [SL-1]) to the public. The single failure criteria (SFC) apply to these engineered features. Operator actions may be credited in place of redundant equipment if the time to reach a hazardous condition was more than 2 weeks (336 hours).

- Engineered protective features were provided for events with high (SL-1) consequences to the co-located worker and moderate to low (SL-2 or lower) consequences to the public if the time to reach a BOC was less than 96 hours. If the time to reach a hazardous condition was sufficiently long (greater than 96 hours), operator action may be credited with performing necessary safety functions in place of engineered protective features. The SFC was applied to engineered features when the time to BOC was less than 12 hours.
- If the consequences to the facility worker were high and the consequences to the co-located worker were not high (SL-2 or lower), administrative controls may be credited with performing necessary safety functions. The SFC was not applied.

These HPAV evaluation criteria were not evaluated for acceptability or adequacy by the Design Oversight Team.

For each of the piping systems analyzed, BNI prepared a detailed piping matrix for each pipe that listed pipe size, volume, safety class, type of waste, hydrogen generation rate, time to BOC, etc. The objectives of the BNI evaluation were (1) to prevent the accumulation and potential ignition of hydrogen in WTP piping and ancillary vessels, and (2) to show that, if hydrogen were to accumulate and detonate, the piping or vessel integrity would not be breached. Both of these approaches protect against hydrogen detonations that could cause unacceptable exposures to workers and the public. The focus of the evaluations was based on safety; namely, to ensure that either hydrogen would not accumulate to detonable levels due to design features, engineered features or operator actions or that the piping and ancillary vessels would remain elastic during a hydrogen explosion and that the pipe boundary bulk confinement function would be maintained.

As part of the overall resolution of the HPAV issue, BNI identified a set of generic solutions involving new and existing engineered controls, design features, and administrative controls for the prevention or mitigation of hydrogen accumulation and explosion. ORP's technical evaluation of these generic solutions is the subject of this Design Oversight Report.

3.0 OBJECTIVES, SCOPE, AND APPROACH

3.1 Objectives

The objectives of this Design Oversight were to:

1. Determine the technical acceptability, viability, and effectiveness of the proposed HPAV generic solutions.
2. Identify any impacts to the WTP flowsheet, throughput, risk register, safety/authorization basis, or total operating efficiency.
3. Determine if proposed operational requirements/expectations are consistent with equipment access, staffing, coincidental operating requirements, etc.
4. Determine if proposed HPAV generic solutions are adequately supported by Research and Technology (R&T) program results.

3.2 Scope

This oversight included review of (1) documents prepared by BNI to standardize and control the HPAV hazards evaluation; (2) the documented criteria against which the HPAV solutions were evaluated for acceptability; (3) WTP engineering documents issued or revised to implement the controls necessary to prevent hydrogen accumulation to explosive levels in WTP piping and ancillary vessels; (4) studies performed by BNI to document the impact to plant availability and the additional burdens placed on plant operators resulting from implementation of the HPAV generic solutions; and (5) R&T results for work performed in support of the HPAV generic solutions.

3.3 Approach

Since the primary objective of this design oversight was the technical evaluation of the HPAV generic solutions involving new and revised systems and components, a Design Oversight Team was identified that was comprised of ORP engineers and contractors possessing expertise on vitrification systems design and mechanical systems design, construction, and operation. The Design Oversight Team was provided with relevant documentation on the determination and implementation of HPAV generic solutions prior to the start of the assessment, including:

- HPAV Design Product Oversight Plan;
- BNI Position Paper on the Evaluation and Control of Hazards Associated with Hydrogen Accumulation in Pipes and Ancillary Vessels (Reference 5);
- Authorization Basis Amendment Requests (ABAR) proposing changes to the PTF and HLW PSARs to implement controls for the HPAV generic solutions (References 6 and 7);
- New and marked-up PTF and HLW piping and instrumentation diagrams (P&ID) implementing the HPAV generic solutions (References 8 through 66);
- HPAV Control Tracking Forms used to document concurrence of BNI's Hydrogen Review Committee with the proposed HPAV generic solutions;
- External Guidance and Review team (EGRT) HPAV-related presentations;
- HPAV ISM meeting minutes (References 67 through 90); and
- BNI HPAV Plant Availability Assessment (Reference 91).

3.3.1 Review and Identify, Resolve, or Document Issues

Questions generated by Design Oversight Team members during the review of the HPAV generic solutions were compiled by the ORP Review Team Lead and submitted to BNI for response. Appendix A is a summary table of the ORP questions and BNI responses. Meetings with cognizant BNI personnel to discuss the ORP questions and proposed BNI responses were held on June 9 and 12, 2006. Appendix B is a summary table of the resolution of the lines of inquiry identified in the HPAV Design Oversight Plan (Appendix C).

3.3.2 Reporting

ORP and BNI management were periodically de-briefed, as necessary, and the draft report summarizing the activities, results, conclusions, and recommendations of the review was issued for review and comment by ORP management and cognizant BNI personnel.

3.3.3 Documentation

This final report organization is based on the sections and content as summarized in Appendix C.

The Open Items and recommendations identified during this oversight are listed in Table 1. Each open issue and recommendation is assigned an item number and will be tracked to resolution through the DOE/ORP Consolidated Action Reporting System (CARS). These open issues will also be tracked to resolution by BNI using RITS; assigning a separate item for each Open Item identified in this Design Oversight Report.

3.3.4 Closure

The Team Leader with concurrence of the WTP Engineering Director will confirm that the Open Items and recommendations from this oversight are adequately resolved.

4.0 RESULTS

4.1 Technical Acceptability, Viability and Effectiveness of the Proposed HPAV Generic Solutions

Prior to and as preparation for evaluating the technical acceptability, viability, and effectiveness of the proposed HPAV generic solutions, the Design Oversight Team reviewed the following BNI HPAV-related documents:

- BNI memorandum CCN:123919, Attachment 3 *(BNI Position Paper), Evaluation and Control of Hazards Associated with Hydrogen Accumulation in Pipes and Ancillary Vessels* (Reference 5);
- ABARs 24590-WTP-SE-ENS-04-0197 and -05-0076 (References 2 and 3);
- 24590-WTP-GPG-ENG-091, *Guide - Hydrogen Accumulation in Pipes and Ancillary Vessels* (Reference 92);
- HPAV ISM meeting minutes (References 67 through 90); and
- HPAV Control Forms used to document proposed HPAV generic solutions for review and concurrence by the BNI Hydrogen Review Committee.

These documents provided the Design Oversight Team with knowledge of the process used by BNI to evaluate the hazards associated with hydrogen accumulation and explosion in WTP piping and ancillary vessels, the criteria used by BNI to determine the acceptability of proposed HPAV generic solutions, and the results of the BNI HPAV hazards analysis. The Design Oversight Team concluded that the HPAV ISM reviews were well staffed with qualified personnel. In addition, the Design Oversight Team found the ISM meeting minutes to be thorough, detailed, and complete.

Working from this knowledge of BNI's approach to resolution of the HPAV issue, the Design Oversight Team reviewed the following new and revised BNI engineering documentation to assess the technical acceptability, viability, and effectiveness of the proposed HPAV generic solutions:

- PTF and HLW P&IDs, including those new and marked-up P&IDs created to implement the HPAV generic solutions (References 8 through 66, and 93 through 98);
- ABARs proposing changes to the PTF and HLW PSARs to implement controls for the HPAV generic solutions (References 6 and 7);

- An example piping matrix for the Waste Feed Evaporation Process System (FEP) (Reference 99);
- CCNs: 140963 and 139899 concerning the application of pressure reflection calculation - deflagration detonation transition (PRC-DDT) data to pipes and jumpers in PTF and HLW (References 100 and 101);
- BNI e-mails identifying spare equipment (e.g., dipped tubes, RFDs, etc.) removed from WTP process vessels to implement HPAV generic solutions (References 102 and 103);
- BNI calculation 24590-PTF-M6C-PSA-00008, *PSA Demand for Suction Mode Venting of Pulse Jet Mixers & Charge Vessels* (Reference 104);
- BNI calculation 24590-PTF-U0C-10-00010, *Analysis of PTF Vessel Vent and Overflow Systems During PJM and Sparger Operations using HADCRT Computer Code* (Reference 105);
- 24590-QL-H4C-W000-00067-02-00001, *Hanford WTP Hydrogen Bubble in Full Pipe, Calculation C-69089-00-1* (Reference 106);
- Dominion Engineering, Inc. memorandum M-6908-00-19, "Response to DOE Questions Regarding Critical Wave Speed" (Reference 107);
- 24590-QL-H4C-W000-00067-02-00001, *Effects of Acceleration of Waste Slug Due to Hydrogen Explosion, Calculation C-69089-00-13* (Reference 108); and
- BNI calculation 24590-WTP-U0C-50-00004, *Input for the WTP Air Use Diagram* (Reference 109).

Based on the information contained in the above documents, the Design Oversight Team evaluated the following HPAV generic solutions for their technical acceptability, viability and effectiveness:

<u>HLW</u>

- Removal of dipped spare lines or removal of dipped portion of spare lines from vessels HDH-VSL-00003, HOP-VSL-00903/00904, and RLD-VSL-00002, 00007, and 00008.
- Spare reverse flow diverters (RFD) in vessels HLP-VSL-00903/00904 reconfigured to provide a vent path [i.e., RFD discharge line connected to the Submerged Bed Scrubber (SBS) headspace via a vent line].
- Passive high point vent with demister added above the bladder seal of the Canister Rinse Vessel (HDH-VSL-00001) to provide a sufficient path for hydrogen diffusion.
- Canister Decontamination Vessels (HDH-VSL-00002 and 00004), which were reconfigured to create a passive vent path by adding standoffs to the vessel lids to allow hydrogen to diffuse from the vessel headspace.
- Fire protection water systems changed from wet-pipe to pre-action systems in HLW rooms H-0126B, H-B028A, H-B033B, H-B037B, and H-0133/H-B035.
- Purge capability added to the HSH hydraulic system reservoirs supporting equipment in the melter caves (e.g., manipulators and portable shears) to vent the reservoir headspace through a pressure relief valve that vents to a C2 or C3 area with a high-efficiency particulate air

(HEPA) filter on the vent. In addition, the administrative control requiring in-cave components to be isolated from the hydraulic reservoir (via a solenoid-operated valve) whenever the system is not running.

- Increased thickness of the air displacement slurry (ADS) pump housing (schedule 80S equivalent with 5/8 in. internal baffle plate) to increase the resistance to hydrogen explosions.
- Administrative control added to replace the ADS pump discharge piping at 20 year intervals.
- Administrative control added to limit the hydrogen generation rate in vessel RLD-VSL-00008 during spill (high solids waste) recovery actions.
- Administrative control added to flush the Canister Rinse Vessel (HDH-VSL-00001) rinse line prior to entry into the area.
- Administrative control added to store portable hydraulic systems used in the melter caves (e.g., shears) away from high source terms (e.g., vessels and melters) when not in use.

PTF

- Dipped spare lines removed from vessel PWD-VSL-00044.
- Spare RFDs removed from vessels PWD-VSL-00015, 00016, and 00044.
- HLW Lag Storage and Feed Blending Process System (HLP) jumpers reconfigured to eliminate dead legs.
- Spent resin (RDP) transfer lines reconfigured to vent hydrogen to the ion exchange columns.
- Vent lines added at high points on the tube sides of heat exchanger CNP-HX-00001 and reboiler TLP-RBLR-00001.
- Pump and reservoir supply hoses reconfigured to vent hydrogen upward.
- Scout Mode operation implemented to vent hydrogen from PJMs in non-Newtonian vessels UPF-VSL-00002A/B, HLP-VSL-00027A/B, and HLP-VSL-00028.
- Air lines and valves added to provide redundant Suction Mode Venting capability for RFD charge vessels and PJMs in Newtonian vessels FRP-VSL-00002A/B/C/D; HLP-VSL-00022; FEP-VSL-00017A/B; UFP-VSL-00001A/B; PWD-VSL-00033, 00043 and 00044; and CNP-VSL-00003. These changes included reprogramming of the ITS and non-ITS control systems (Programmable Protection System [PPJ] and Process Control System [PCJ], respectively) to perform periodic Suction Mode Venting (post-DBE) and redundant ITS plant service air (PSA) supplies added to the suction sides of the RFD charge vessels and PJMs.
- Air flush/purge capability added to the pump suction and discharge lines for non-Newtonian vessels HLP-VSL-00027A/B (pump suction side only), HLP-VSL-00028 (pump suction side only), and UPF-VSL-00002A/B.
- High point vents added to the pump suction lines for Newtonian vessels FRP-VSL-00002A/B/C/D and TCP-VSL-00001.
- Air flush/purge capability added to the Ultrafiltration Process System (UFP) filtration loop.
- Interlocks added to vessels HLP-VSL-00027A/B and HLP-VSL-00028 to prevent dead leg formation.

- Interlocks added to monitor and control FRP and HLP pump run times.
- Administrative control added to require dead leg flushing prior to pump restart.
- Administrative control added to limit pump run times.
- Administrative control added to sample RDP vessel contents for uneluted resin.

The Design Oversight Team also evaluated acceptable hydrogen accumulation points in both PTF and HLW systems and components identified by BNI, where the time to reach the lower flammability limit (LFL) was calculated to be greater than 1,000 hours and where, if an explosion occurred, the response would not exceed the elastic limit of the material involved.

General Conclusions

The Design Oversight Team concluded that the BNI approach and effort in addressing the HPAV issue were comprehensive and thorough (based on the information reviewed and discussions with cognizant personnel held during the course of the assessment). While not specifically evaluated during this design oversight and the subject of other ORP reviews in progress, it appeared to the Design Oversight Team that the BNI efforts to analyze the potential for hydrogen accumulation (whether from gases generated from waste streams or from radiolysis of water streams) in the piping and ancillary vessels was conservative and bounding for conditions expected in WTP. It also appeared to the Design Oversight Team that the full range of potential sites for detonations of the accumulated hydrogen were identified and evaluated in the areas of concern; primarily in PTF and HLW.

The BNI evaluations of the potential for hydrogen detonations identified measures that are required to maintain the plant in a safe condition (e.g., protect the health and safety of the public, co-located worker and facility worker). These measures focus on ensuring the integrity of the first line of containment in the event of a detonation (e.g., piping and vessels), either by providing design features or ITS engineered features to prevent accumulation of hydrogen, or by confirming the integrity of the components under postulated worse case detonation conditions. In addition to the safety case, BNI identified additional actions that are to be taken to minimize the impact of potential detonations on the availability of affected systems and components. These additional preventive measures minimize the potential for accumulation of hydrogen to detonable levels, (e.g., ensuring that static waste streams are flushed clean before significant levels of hydrogen can be generated).

The Design Oversight Team noted, however, that the BNI work on addressing HPAV is not complete. For example, BNI has yet to complete the development and reconciliation of the safety case and availability piping matrices, the design and application of HPAV engineered features to the plant, and the assessment of HPAV impacts on PTF and HLW availability. In addition, there are several open items from the BNI EGRT reviews that have to be resolved. These open items parallel some of the areas that were reviewed by the Design Oversight Team and resulted in some of the Open Items discussed later in this assessment report.

Review of HPAV Generic Solutions

As noted above, BNI developed several generic solutions to address HPAV concerns in specific plant configurations. The HPAV generic solutions also impact the operation of some facility support systems (e.g., waste water treatment, air compressors). The following paragraphs discuss the Open Items identified by the Design Oversight Team's evaluation of the technical acceptability, viability, and effectiveness of the proposed HPAV generic solutions and the basis for each Open Item.

Open Item No. 1 – Pump Suction Air Purge System

BNI shall evaluate the design of the isolation between WTP waste-containing systems and interfacing utility systems. Specifically, BNI should evaluate the need for the use of a block and bleed isolation configuration instead of a double isolation valve design to allow the venting of any leakage into the cross-connect between the isolation valves from leakage through either valve. The results of this evaluation shall be provided to ORP.

The Design Oversight Team questioned the design of the air purge system for the UFP. Specifically, the PSA system purge air to UFP is controlled through the use of plug valves. In the higher pressure sections of the UFP system, it appeared to the Design Oversight Team that leakage through the plug valves or the inadvertent opening of a plug valve during normal operations, particularly on the loss of the PSA system, could result in contamination of the PSA system. The Design Oversight Team questioned BNI as to the design or other features that prevent this possible contamination event that could affect large portions of WTP. BNI responded that the PSA air supply is backed up by the ITS air supply and both air system pressures are significantly higher that the UFP pressure at the PSA/UFP interface. In addition, the design includes two normally closed isolation valves between the PSA/ITS air supply systems and the UFP system.

Although the Design Oversight Team found the BNI response acceptable for resolving the concern about the potential for contamination of the PSA system, Open Item No. 1 above was identified concerning a potential weakness in the design of HPAV generic solutions involving the isolation interface between plant utility systems and waste processing systems.

Open Item No. 2 – Suction Mode Venting and Scout Mode PJM and RFD Charge Vessel Operation

BNI shall review the adequacy of the calculation (24590-PTF-M6C-PSA-00008) assumption that the PJM is full of waste when determining the frequency, number of cycles, and timing of cycles for the Suction Mode Venting operation of PJMs. Specifically, BNI should consider the case of a PJM that is not full of waste and the impact, if any, on hydrogen accumulation in the PJM during Suction Mode venting operation. The results of this review shall be provided to ORP.

The Design Oversight Team questioned the existence of calculations or other documentation that provide a technical basis for concluding that the Scout Mode (non-Newtonian vessels) and Suction Mode Venting (Newtonian vessels) provide adequate venting of hydrogen from PJMs and RFD charge vessels installed within these vessels (i.e., preclude the accumulation of significant quantities of hydrogen in the PJMs and RFD charge vessels). BNI responded that calculation 24590-PTF-M6C-PSA-00008 (Reference 104) discusses the functions and air usage during suction mode venting.

This calculation, dealing with the required frequency and cycle timing for the Suction Mode Venting mode of PJM operation, assumes that the PJM is full when suction mode venting is initiated. This will not be the case if the vessel level is below the top of the PJM. If the current timing and number of cycles were applied in this condition, the PJM would not be fully vented of hydrogen on each stroke and the hydrogen concentration at the end of suction mode venting may be higher than currently calculated.

Open Item No. 3 – Suction Mode Venting and Scout Mode PJM and RFD Charge Vessel Operation

BNI shall provide ORP with an evaluation of the air demand during post-DBE Suction Mode Venting or Scout Mode operation of the PJMs and RFD charge vessels that shows that the air demand does not exceed the capacity of the ITS compressors. In addition, BNI shall determine and document the impact that post-DBE operation of the three ITS air compressors will have on the loading of the facility emergency diesel generators, accounting for HPAV-related air loads in addition to those required for other post-DBE functions. This documentation shall be provided to ORP.

BNI provided the Design Oversight Team a reference to the WTP Air Use Diagram, including calculation 24590-WTP-U0C-50-00004 (Reference 109) that provides inputs to the Air Use Diagram. The Design Oversight Team found the calculations and Air Use Diagram generally acceptable; however, Open Item No. 3was identified, as discussed further in the following paragraph.

If the post-DBE Suction Mode Venting and Scout Mode air demands were simultaneously applied to the ITS compressors, the air demand would exceed the capacity of the compressors. BNI indicated their intention to sequence post-DBE air supplies to the PJMs and RFD charge vessels; however, the PPJ control logic/sequencing for the ITS air compressors was not available for review by the Design Oversight Team. In addition, BNI had not determined the impact, if any, that post-DBE operation of the three ITS air compressors will have on the loading of the facility emergency diesel generators.

Open Item No. 4 – Pump Suction High Point Vents

BNI shall provide ORP with an evaluation that shows that the HPAV generic solution involving the addition of high point vents on pump suctions will operate properly following a design basis event involving PVP pressurization/loss of vacuum.

The Design Oversight Team questioned the technical basis for concluding the HPAV generic solution involving the addition of high point vents on pump suctions would operate properly following a DBE. Specifically, the team questioned if the venting function could be compromised due to post-DBE pressurization of the PVP; particularly for the vent added to the pump suction for vessel TCP-VSL-00001. BNI responded by providing calculation 24590-PTF-U0C-10-00010, *Vessel Vent and Overflow Systems During PJM and Sparger Operations Using HADCRT Computer Code* (Reference 105). Based on subsequent review of the calculation, the Design Oversight Team determined the calculation did not address the question on high point vent operation.

Open Item No. 5 – Dead Leg Flushing

BNI shall provide ORP with the evaluation of the amount of water required to perform line flushes required to implement HPAV generic solutions and the basis for concluding that flowsheet impacts due to this additional water have been optimized and are acceptable.

The Design Oversight Team questioned the technical basis for concluding that dead legs and blank lines are effectively flushed following waste transfers in piping headers attached to the dead legs and/or blank lines. BNI responded that all dead legs and/or blank lines on a piping header used for a waste transfer will be flushed through to the destination vessel following every transfer. In addition, a check is made to ensure that the frequency and duration of transfers that affect a set of dead legs and/or blank lines is adequate to preclude the formation of a BOC in a dead leg or blank line between flushes. However, no credit is taken for waste transfers that are frequent enough to preclude the need to flush dead legs/blank lines after each transfer. These dead leg/blank line flushes and other flushes required to implement HPAV generic solutions result in a significant increase in the amount of waste water handled by the facility. BNI has not fully evaluated the impact to the facility flowsheet from this additional waste water or if the frequency of dead leg/blank line flushes can be reduced to minimize the flowsheet impact.

<u>Open Item No. 6 - Piping and Vessel Loads Attendant to Hydrogen Detonation</u>

BNI shall provide ORP with an evaluation of the potential for oscillatory loads to be imposed on WTP piping if there is the potential that the fluid boundaries may not be incompressible, the impact of the high-speed injection of a waste slug or bubble into vessel HLP-VSL-00022 (and other WTP vessels, as appropriate), and the potential for and consequences of a post-detonation water hammer event in the affected piping.

Since this is part of the HPAV generic solution set, the Design Oversight Team evaluated the analyses performed by BNI and its contractors (e.g., Dominion Engineering, Inc. [DEI]) to establish the acceptability of allowing hydrogen to accumulate and detonate in WTP piping and ancillary vessels. The Design Oversight Team did not evaluate the deflagration/detonation methodology (i.e., BOC methodology, pressure reflection calculation [PRC] methodology, or deflagration/detonation transition [DDT] methodology) or the hydrogen generation rate phenomenology. Rather, the Design Oversight Team's focus was on the impact to plant availability from hydrogen explosions and detonations in piping and ancillary vessels. Specifically, the Design Oversight Team questioned if HPAV calculations considered the impact of detonations on piping and ancillary vessel materials other than stainless steel, if the UFP recirculation pump discharge pressure was within the range of pressures analyzed by the DEI BOC calculation (C-6908-00-1), and the impact of compressible boundaries and other factors not expressly considered in the DEI BOC calculations on the calculated loads.

BNI responded that the only other material of interest is Hastelloy. The properties of Hastelloy were checked and it was determined by BNI that, if 316 stainless steel remained in the elastic range under detonation loads, then the same would be true for Hastelloy. This conclusion is addressed as an assumption in one of the HPAV ABARs (Assumption No. 12 in 24590-WTP-SE-ENS-05-041, Reference 7) and in Section 4.3 of CCN: 116909, p. 4 of 29 (Reference 79).

- BNI further identified that the UFP pump discharge pressure (114 psig) is lower than the maximum pump discharge pressure assumed in DEI's BOC calculation (172 psig) and, although the UFP design is not complete, the pump discharge pressure is not expected to significantly increase.
- A DEI memorandum (M-6908-00-19, Reference 107) addressing a DOE question on critical wave speed was provided to the Design Oversight Team. However, the memorandum did not address the Design Oversight Team's concern with the potential for oscillatory loads that could be generated if the fluid boundaries are compressible instead of rigid.

During discussions with BNI personnel on the concern about the potential for piping and components to be subjected to loads caused by oscillatory loads generated by compressible fluid boundaries, the Design Oversight Team identified further concerns with the DEI calculations.

- The first concern is that the DEI calculations completed to date do not appear to have considered the pressure response and loading in the pipe as it refills with waste after the waste slug is ejected. In this regard, the following effects should be considered:
  - Oscillatory loads (that may present fatigue concerns) as the waste refills the pipe against any remaining gases, and/or
  - The potential for "water hammer" as the waste re-enters the pipe, if a void has been created either due to condensation of water or water vapor that was evaporated by the temperature spike attendant to the detonation or condensation of the detonation gases.

  The Design Oversight Team noted that BNI is reviewing the loads on the piping supports and displacements of the piping under PRC detonation loads. While these loads may bound any post-detonation water hammer type loads, this analysis had not been completed at the time of the assessment.

- The second concern resulted from Design Oversight Team review of DEI calculation C-6908-00-13, *Effects of Acceleration of Waste Slug Due to Hydrogen Explosion* (Reference 108). This calculation examined the long-term behavior of a waste slug in a line connected to vessel HLP-VSL-00022. The calculation showed that the line is completely evacuated with the slug ejected into the vessel with significant velocity. However, the calculation does not address the potential impact of the slug or the gas bubble entering the vessel at high velocity. It also does not address the conditions in the piping on refill.

Open Item No. 7 – HPAV Concerns for the Analytical Laboratory

BNI shall provide ORP with the ISM meeting minutes documenting the basis for not applying the HPAV generic solutions to the WTP Analytical Laboratory.

The Design Oversight Team questioned why the Analytical Laboratory was determined by BNI to be out of the scope for the HPAV study. BNI responded that the potential for hydrogen generation in the Analytical Laboratory was determined to be sufficiently low as to not necessitate the need for implementation of an HPAV generic solution(s). BNI further noted that this determination was made in an Analytical Laboratory ISM meeting; however, the ISM meeting minutes were not provided to the Design Oversight Team.

Removal of Spare Components

Finally, the Design Oversight Team questioned the number of spare components (e.g., dipped tubes, RFDs) removed from PTF and HLW vessels and the impact of this removal on plant availability. BNI provided this information in two e-mails (References 102 and 103) and indicated that the removal of these spares had an insignificant impact on plant availability. Based on the limited amount of spare equipment removed and that the functions to be performed by much of the equipment had already been deleted from the plant design (e.g., the spare RFDs removed from PTF were originally intended to provide a means to obtain samples from the host vessels; however, the sampling function was removed from the design prior to the HPAV study), the Design Oversight Team agreed with the BNI conclusion that the plant availability impact was inconsequential. No Open Items were identified for the removal of these spare components.

4.2 Impacts to the WTP Flowsheet, Throughput, Risk Register, Safety/Authorization Basis, or Total Operating Efficiency

To assess the impacts to the WTP flowsheet, throughput, risk register, safety/authorization basis, or total operating efficiency (TOE), the Design Oversight Team evaluated the following additional documents:

- BNI HPAV Plant Availability Assessment (Reference 99)
- BNI memorandum CCN:134821, *Desktop Instructions for Plant Availability* (Reference 110).

<u>Open Item No. 8 – Potential for Hydrogen Deflagrations/Detonations to Impact Plant Availability</u>

BNI shall assess the impact of temperature spikes that occur during hydrogen detonations in WTP piping and ancillary vessels on the post-detonation functionality of affected components (e.g., pumps, valves, instruments, seals, gaskets) and the impact of the repair or replacement of these components on plant availability. The results of these evaluations and any other evaluations that assess the impact of HPAV-related risks on plant availability shall be provided to ORP.

The Design Oversight Team determined that the BNI evaluations of the impact of implementation of the HPAV generic solutions on plant availability were not complete. During meetings with the Design Oversight Team, BNI indicated that hydrogen detonations may occur during normal operations involving hydrogen bubble sizes less than the calculated bubbles of concern. However, the energy potential of these expected detonations has not been determined. These detonations are not of concern for the safety case, since they are bounded by the BOCs. However, BNI has not determined if components in the affected systems would be functional after exposure to the high temperature spike associated with the detonation, (e.g., failure of valves, pumps, seals, gaskets, instrumentation). These components may have to be replaced before resumption of operations after the detonation. (Note: DEI has evaluated a limited set of components for the hydrogen detonation pressure pulse, but not for the temperature spike associated with the detonation.)

The Design Oversight Team concluded that the BNI evaluations of hydrogen detonations from bubbles smaller than the BOC and the resultant impacts on plant availability due to detonation-caused damage to plant systems and components should consider the following:

- Development of the expected frequency and impact of potential hydrogen detonations on the functionality of affected systems and components. This should include developing:
  - Realistic assessments of the potential for hydrogen generation and accumulation, conditions for deflagration and transition to detonation;
  - Evaluation of the impact of a deflagration and/or detonation on the functionality of components in the affected systems; and
  - Establishing the time to repair, if damage is anticipated.

- Combining this data with similar data on the reliability of the HPAV-based engineered features added to the plant to establish the overall impact of HPAV on the availability of PTF and HLW.

The results of these evaluations should then be added to the current availability assessments for WTP to understand the full impact on plant throughput (Contract requirement C-7(b)).

Effect of HPAV Generic Solution Design Features on Plant Availability

Open Item No. 9

BNI shall evaluate the fail open design of the purge air isolation valves in the air racks supplying the UFP pump suction line to determine if the potential impact to plant availability could be reduced through the use of a fail close valve design. The results of this evaluation shall be provided to ORP.

The Design Oversight Team questioned the consequences of the failure of the normally closed, fail open, air-operated isolation plug valve isolating the UFP pump suction line from the non-ITS PSA air supply system. BNI responded that, if this isolation valve were to fail open during normal plant operations, the UFP pump would likely fail due to cavitation. BNI has not evaluated the probability of this pump failure versus the probability of a hydrogen detonation in the UFP pump suction line under static conditions. The Design Oversight Team questioned the need for this valve to fail open, since redundant, separate ITS purge air supply trains are provided as backup for this function. A fail closed valve would provide better protection against pump failure due the inadvertent opening of the purge air supply valve. During the factual accuracy review, BNI identified that the isolation plug valve must fail open to ensure the ability to purge the line between the seismic isolation valve and UFP vessels UFP-VSL-00002A/B. However, it was not obvious to the Design Oversight Team why the purge air isolation valves in the air racks supplying the UFP pump suction line must also be a fail open design.

Open Item No. 10

BNI shall evaluate the need for a redundant supply of purge air to the UFP system (i.e., the air purge for the UFP piping, heat exchangers, filters, and pump). The results of this evaluation shall be provided to ORP.

As discussed above, the Design Oversight Team questioned the design of the purge air supply to the UFP system (see Open Item No. 1). During discussions with BNI personnel, it was identified that the design of the purge air supply to the mid-section of the UFP loop involved a single (i.e., not redundant) purge air supply line. Although BNI concluded that a potential detonation in this part of the UFP system was not a safety issue, such a detonation could impact the availability of this PTF process system. In this regard, the Design Oversight Team identified Open Item No. 10.

4.3 HPAV-Related Operational Requirements/Expectations

Open Item No. 11 – Configuration Management of HPAV Generic Solutions

BNI shall provide ORP with documentation of changes made to the formal Configuration Management Program to account for HPAV items.

Based on the information available at the time of this design oversight, it appeared to the Design Oversight Team that there were a significant number (i.e., thousands) of measures that were or will be taken to address the HPAV issue. These measures include reliance on design features (e.g., maintaining slopes in pipes to prevent the accumulation of hydrogen to a detonable level and adequate pipe schedules to ensure that the pipes can remain elastic when subjected to detonation loads); additional operational constraints (e.g., requiring completion of transfers and initiation of flushes within specific time frames); and additional engineered controls (e.g., air purges of pump suction lines in systems handling non-Newtonian fluids, adding redundancy and additional cycling logic to the operation of PJMs in Newtonian vessels) to prevent the accumulation of hydrogen to detonable levels. Many of these measures result from the project's safety case and are currently slated to become a part of the technical safety requirements for the plant; requiring special control and surveillance during the completion of design, construction, testing and operation of the plant. The other HPAV measures are being taken to minimize the impact to plant availability from HPAV-related detonations. It was unclear to the Design Oversight Team at the time of the assessment how many of these measures fall into each category. Matrices that define the measures taken for each pipe and ancillary vessel for both the safety case and for plant availability have not been completed and reconciled.

Implementation of this large number of HPAV measures presents a significant configuration management (CM) burden on the project and adds many operational constraints on the operators and operation of the plant. Many of these measures involve monitoring and control by the Programmable Protection (PPJ, ITS) and Process Control (PCJ, non-ITS) systems (e.g., the timing and control of transfers and flushes, Suction Mode Venting operation of the PJMs), adding significant complication to developing, verifying, and validating the efficacy of the logic supporting these controls.

To promote adequate control of these HPAV measures, the Design Oversight Team concluded that BNI should ensure the HPAV items are fully accounted for in its formal Configuration Management Program (CMP). Accordingly, the Design Oversight Team questioned if the BNI CMP had been revised to include consideration of HPAV for future design, procedure, and program changes (i.e., to ensure HPAV considerations are included in the change process, including field change requests during plant construction and testing). BNI responded that updating of the BNI CMP to address HPAV was ongoing and noted further that this was also an open item from the EGRT review. The Design Oversight Team decided that Open Item No. 11 was warranted to ensure that ORP is fully engaged on changes made to the project's CMP to address HPAV generic solution implementation. In addition, the Design Oversight Team believes it would be prudent for ORP to consider assessing the effectiveness of BNI's configuration management of the implemented HPAV generic solutions as part of any future assessments of the CMP (see Recommendation below).

In developing the HPAV measures for the safety case, it appeared to the Design Oversight Team that BNI applied conservative assumptions in each phase of the evaluations. As a result, the Design Oversight Team believes there is considerable margin between the calculated conditions for HPAV and the actual conditions expected during operation of the plant. The Design Oversight Team expects that assessments of the impact of HPAV on plant availability will provide a more realistic estimate of the expected HPAV risk (e.g., annual probability of a detonation that affects system operation), since the availability assessment should be based on expected operating conditions in the plant, including expected hydrogen generation, accumulation, deflagration, detonation, and impact on plant systems and components. The Design Oversight Team believes these assessments may provide a basis for re-evaluating the necessary level of control required for certain of the HPAV measures, (e.g., surveillance of pipe slopes post-construction), possibly allowing a reduction in the CM burden during operation.

The Design Oversight Team also considered the potential benefit to future plant operations from the addition of hydrogen monitoring capability to monitor actual hydrogen generation rates in key locations (e.g., in non-Newtonian vessels) during plant operation. Hydrogen generation rate measurements over time, combined with the results of the assessment of HPAV impacts on plant availability, could provide a basis for re-evaluating the specific requirements for control and implementation of the HPAV operational constraints and engineered features. Based on meetings with BNI personnel, it is the Design Oversight Team's understanding that BNI is actively pursuing the addition of hydrogen monitoring capability to the WTP design in response to commitments made to the Defense Nuclear Facilities Safety Board (References 111 and 112) and as documented as a recommendation by ORP in an earlier design oversight report on Hydrogen Mitigation and Control Systems (Reference 113).

The Design Oversight Team was unable to come to a definitive conclusion concerning the burden on plant operators associated with implementation of the HPAV generic solutions. As noted previously, the PPJ and PCJ systems will largely monitor and control the myriad of flushes, purges, Suction Mode Ventilation operation and Scout Mode operation of PJMs, and other functions required to implement the HPAV generic solutions. Identified burdens to the project include the proper programming and testing of the plant systems controlling the HPAV functions to confirm they function as intended and maintenance of the viability of the HPAV controls through the project's formal CMP.

Recommendation

While the Design Oversight Team identified no issues or Open Items associated with the operational requirements/expectations for the HPAV generic solutions, ORP should consider making these operational aspects an area of interest in future assessments as the associated processes and procedures are further developed.

4.4 Research and Technology Program Results Support of the HPAV Generic Solutions

The Design Oversight Team evaluated R&T work performed by BNI in support of implementation of the HPAV generic solutions (References 114 and 115) and assessed if additional R&T work is necessary. BNI completed two testing programs in support of the design and implementation of the HPAV engineered solutions. Post-DBE UFP-VSL-00002A/B Pump Supply Line Clearing Tests were conducted on a full-scale mockup of this line at the Savannah River National Laboratory (SRNL). These tests confirmed the ability of an air purge to remove at least 70% of high shear stress simulant from the UFP pump suction line and provided requirements on the flow rate and duration of the purge to meet this condition.

The PJM Non-Newtonian "Slug" Internal Mixing Tests, performed at the Pacific Northwest National Laboratory (PNNL), confirmed that half stroke operation of the PJMs would not fully mix the retained waste with new waste; a condition that could lead to unacceptable concentration of hydrogen in the PJM. These tests also confirmed that "full stroke" (85% of the length of the PJM) fully mixed new waste with retained waste in the PJM. This testing program will be used to establish the functional requirements for the Scout Mode of PJM operation. Additional testing is planned to show that adequate mixing occurs with less than 10 full stroke cycles.

No additional R&T needs were identified by the Design Oversight Team and no R&T-related Open Items were identified.

5.0 OPEN ITEMS AND RECOMMENDATIONS

The following Open Items and Recommendations have been identified by the HPAV Generic Solutions Design Oversight Team. Successful completion of these Open Items and Recommendations will support ORP's review of HPAV-related changes to the project Authorization Basis and the eventual ORP conclusion that implementation of the HPAV generic solutions provides reasonable assurance that the potential for hydrogen accumulation and detonation in WTP piping and ancillary vessels does not pose unacceptable risk to the public, co-located or facility workers, or the environment and does not unduly impact plant availability.

Table 1. List of Open Items and Recommendations from the ORP HPAV Generic Solutions Design Oversight

Open Item Number	Open Item
1	BNI shall evaluate the design of the isolation between WTP waste-containing systems and interfacing utility systems. Specifically, BNI should evaluate the need for the use of a block and bleed isolation configuration instead of a double isolation valve design to allow the venting of any leakage into the cross-connect between the isolation valves from leakage through either valve. The results of this evaluation shall be provided to ORP.
2	BNI shall review the adequacy of the calculation (24590-PTF-M6C-PSA-00008) assumption that the PJM is full of waste when determining the frequency, number of cycles, and timing of cycles for the Suction Mode Venting operation of PJMs. Specifically, BNI should consider the case of a PJM that is not full of waste and the impact, if any, on hydrogen accumulation in the PJM during Suction Mode venting operation. The results of this review shall be provided to ORP.
3	BNI shall provide ORP with an evaluation of the air demand during post-DBE Suction Mode Venting or Scout Mode operation of the PJMs and RFD charge vessels that shows that the air demand does not exceed the capacity of the ITS compressors. In addition, BNI shall determine and document the impact that post-DBE operation of the three ITS air compressors will have on the loading of the facility emergency diesel generators, accounting for HPAV-related air loads in addition to those required for other post-DBE functions. This documentation shall be provided to ORP.
4	BNI shall provide ORP a with an evaluation that shows that the HPAV generic solution involving the addition of high point vents on pump suctions will operate properly following a design basis event involving PVP pressurization/loss of vacuum.
5	BNI shall provide ORP with the evaluation of the amount of water required to

Table 1. List of Open Items and Recommendations from the ORP HPAV Generic Solutions Design Oversight

Open Item Number	Open Item
	perform line flushes required to implement HPAV generic solutions and the basis for concluding that flowsheet impacts due to this additional water have been optimized and are acceptable.
6	BNI shall provide ORP with an evaluation of the potential for oscillatory loads to be imposed on WTP piping if there is the potential that the fluid boundaries may not be incompressible, the impact of the high-speed injection of a waste slug or bubble into vessel HLP-VSL-00022 (and other WTP vessels, as appropriate), and the potential for and consequences of a post-detonation water hammer event in the affected piping.
7	BNI shall provide ORP with the ISM meeting minutes documenting the basis for not applying the HPAV generic solutions to the WTP Analytical Laboratory.
8	BNI shall assess the impact of temperature spikes that occur during hydrogen detonations in WTP piping and ancillary vessels on the post-detonation functionality of affected components (e.g., pumps, valves, instruments, seals, gaskets) and the impact of the repair or replacement of these components on plant availability. The results of these evaluations and any other evaluations that assess the impact of HPAV-related risks on plant availability shall be provided to ORP.
9	BNI shall evaluate the fail open design of the purge air isolation valves in the air racks supplying the UFP pump suction line to determine if the potential impact to plant availability could be reduced through the use of a fail close valve design. The results of this evaluation shall be provided to ORP.
10	BNI shall evaluate the need for a redundant supply of purge air to the UFP system (i.e., the air purge for the UFP piping, heat exchangers, filters and pump). The results of this evaluation shall be provided to ORP.
11	BNI shall provide ORP with documentation of changes made to the formal Configuration Management Program to account for HPAV items.
	Recommendation
1	While the Design Oversight Team identified no issues or Open Items associated with the operational requirements/expectations for the HPAV generic solutions, ORP should consider making these operational aspects an area of interest in future assessments as the associated processes and procedures are further developed.

6.0 REFERENCES

1. Information Notice 2002-15, U. S. Nuclear Regulatory Commission, April 12, 2002, *Hydrogen Combustion Events in Foreign BWR Piping.*
2. 24590-WTP-SE-ENS-04-0197, BNI Safety Evaluation for Design, Rev. 0, September 14, 2005, *Implementation of Revised Time Basis for Single Failure Criteria for Hydrogen Mitigation.*
3. 24590-WTP-SE-ENS-05-0076, BNI Safety Evaluation for Design, Rev. 0, September 14, 2005, *Acceptance Criteria for Hydrogen Explosions in Piping and In-Line Components.*
4. ORP letter 06-WTP-042, R. J. Schepens to J. P. Henschel, BNI, April 17, 2006, "Partial Disapproval of Bechtel National, Inc. (BNI) Authorization Basis Amendment Requests (ABAR) Requesting use of Inelastic Material Properties Following Hypothetical Hydrogen Explosions in Piping and Ancillary Vessels."
5. CCN: 123919, Attachment 3 (BNI Position Paper), *Evaluation and Control of Hazards Associated with Hydrogen Accumulation in Pipes and Ancillary Vessels.*
6. 24590-WTP-SE-ENS-05-0040, Rev. 0, March 20, 2006, *Implementation of Controls for Hydrogen in HLW Facility Piping and Ancillary Vessels (HPAV).*
7. 24590-WTP-SE-ENS-05-0041, Rev. 0, March 20, 2006, *Implementation of Controls for Hydrogen in PT Facility Piping and Ancillary Vessels (HPAV).*
8. 24590-HLW-M6-HOP-00001, (HPAV Study Mark-Up Piping & Instrumentation Diagram [P&ID]), *HLW Melter Offgas System 1, Primary Offgas Scrubber.*
9. 24590-HLW-M6-HOP-00006, (HPAV Study Mark-Up P&ID), *HLW Melter Offgas System 1, Primary Offgas Scrubber Condensate Vessel.*
10. 24590-HLW-M6-HOP-20001, (HPAV Study Mark-Up P&ID), *HLW Melter Offgas System 2, Primary Offgas Scrubber.*
11. 24590-HLW-M6-HOP-20006, (HPAV Study Mark-Up P&ID), *HLW Melter Offgas System 2, Primary Offgas Scrubber Condensate Vessel.*
12. 24590-HLW-M6-HDH-00002, (HPAV Study Mark-Up P&ID), *HLW Canister Decontamination Handling System.*
13. 24590-PTF-M6-CNP-00003, (HPAV Study Mark-Up P&ID), *PTF Cesium Nitric Acid Recovery Utility Services – PSA Rack.*
14. 24590-PTF-M6-FEP-00006, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Evaporation Utility Services PSA Rack.*
15. 24590-PTF-M6-FEP-00007, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Evaporation Utility Services PSA Rack.*
16. 24590-PTF-M6-FRP-00001, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Vessels FRP-VSL-00002A and FRP-VSL-00002B.*
17. 24590-PTF-M6-FRP-00002, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Vessels FRP-VSL-00002C and FRP-VSL-00002D.*

18. 24590-PTF-M6-FRP-00005, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
19. 24590-PTF-M6-FRP-00006, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
20. 24590-PTF-M6-FRP-00007, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
21. 24590-PTF-M6-FRP-00008, (HPAV Study Mark-Up P&ID), P*TF Waste Feed Receipt Utility Services – PSA Rack.*
22. 24590-PTF-M6-FRP-00017, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
23. 24590-PTF-M6-FRP-00018, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
24. 24590-PTF-M6-FRP-00019, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
25. 24590-PTF-M6-FRP-00020, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services – PSA Rack.*
26. 24590-PTF-M6-HLP-00001, (HPAV Study Mark-Up P&ID), *PTF HLP System HLW Lag Storage and Blending Process Vessel HLP-VSL-00027A/B.*
27. 24590-PTF-M6-HLP-00003, (HPAV Study Mark-Up P&ID), *PTF HLP System HLW Lag Storage and Blending Process Vessel HLP-VSL-00028.*
28. 24590-PTF-M6-HLP-00027, (HPAV Study Mark-Up P&ID), Untitled.
29. 24590-PTF-M6-PVP-00028, (HPAV Study Mark-Up P&ID), *PTF Process Vessel/ Vent System Process Condensate Rack.*
30. 24590-PTF-M6-PVP-00029, (HPAV Study Mark-Up P&ID), *PTF Process Vessel Vent System Process Condensate Rack.*
31. 24590-PTF-M6-PWD-00007, (HPAV Study Mark-Up P&ID), *PTF System PWD Plant Wash & Disposal Effluent Collection Header Bulge & Rack Drains.*
32. 24590-PTF-M6-PWD-00020, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services – PSA Rack.*
33. 24590-PTF-M6-PWD-00021, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services – PSA Rack.*
34. 24590-PTF-M6-TCP-00001, (HPAV Study Mark-Up P&ID), *PTF Treated LAW Concentrate Storage System TCP-VSL-00001.*
35. 24590-PTF-M6-UFP-00002, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Vessel UFP-VSL-00002A.*
36. 24590-PTF-M6-UFP-00002, (HPAV Study Mark-Up P&ID), Attached Detail.
37. 24590-PTF-M6-UFP-00003, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Vessel UFP-VSL-00002B.*

38. 24590-PTF-M6-UFP-00003, (HPAV Study Mark-Up P&ID), Attached Detail.

39. 24590-PTF-M6-UFP-00007, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Utility Services – PSA Rack.*

40. 24590-PTF-M6-UFP-00008, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Utility Services – PSA Rack.*

41. 24590-PTF-M6-UFP-00009, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Utility Services – PSA Rack.*

42. 24590-PTF-M6-UFP-00011, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Utility Services – PSA Rack.*

43. 24590-PTF-M6-CXP-00002, (HPAV Study Mark-Up P&ID), *PTF Cesium Ion Exchange Columns System.*

44. 24590-PTF-M6-FRP-00003, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Process System FRP-PMP-00001 and FRP-PMP-00002A.*

45. 24590-PTF-M6-FRP-00009, (HPAV Study Mark-Up P&ID), *PTF Waste Feed Receipt Utility Services Plant Wash Rack.*

46. 24590-PTF-M6-HLP-00001, (HPAV Study Mark-Up P&ID), *PTF HLP System HLW Lag Storage and Blending Process Vessel HLP-VSL-00027A/B.*

47. 24590-PTF-M6-HLP-00002, (HPAV Study Mark-Up P&ID), *PTF HLP System HLW Feed Receipt Vessel HLP-VSL-00022.*

48. 24590-PTF-M6-HLP-00003, (HPAV Study Mark-Up P&ID), *PTF HLP System HLW Feed Blending Process Vessel HLP-VSL-00028.*

49. 24590-PTF-M6-HLP-00009, (HPAV Study Mark-Up P&ID), *PTF HLW Lag Storage & Feed Blending Utility Services - Plant Wash Rack.*

50. 24590-PTF-M6-HLP-00010, (HPAV Study Mark-Up P&ID), *PTF HLW Lag Storage & Feed Blending Utility Services - Plant Wash Rack.*

51. 24590-PTF-M6-PJV-00002, (HPAV Study Mark-Up P&ID), *PTF Pulse Jet Ventilation System Inlet Header to Demister Outlet.*

52. 24590-PTF-M6-PVP-00024, (HPAV Study Mark-Up P&ID), *PTF Process Vessel Vent System PVP-BULGE-00015 & PVP-RK-00021.*

53. 24590-PTF-M6-PVP-00025, (HPAV Study Mark-Up P&ID), *PTF Process Vessel Vent System PVP-BULGE-00016 & PVP-RK-00022.*

54. 24590-PTF-M6-PVP-00027, (HPAV Study Mark-Up P&ID), *PTF Process Vessel Vent System Process Condensate Rack.*

55. 24590-PTF-M6-PWD-00022, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services - Plant Wash Rack.*

56. 24590-PTF-M6-PWD-00026, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services - Plant Wash Rack.*

57. 24590-PTF-M6-PWD-00033, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services - Plant Wash Rack.*

58. 24590-PTF-M6-PWD-00045, (HPAV Study Mark-Up P&ID), *PTF Plant Wash & Disposal Utility Services - Plant Wash Rack.*

59. 24590-PTF-M6-TCP-00001, (HPAV Study Mark-Up P&ID), *PTF Treated LAW Concentrate Storage System TCP-VSL-00001.*

60. 24590-PTF-M6-TLP-00003, (HPAV Study Mark-Up P&ID), *PTF Treated LAW Evaporation Process System Separator TLP-SEP-00001.*

61. 24590-PTF-M6-UFP-00001, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration Feed Preparation System Vessels UFP-VSL-00001A/B.*

62. 24590-PTF-M6-UFP-00002, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Vessel UFP-VSL-00002A.*

63. 24590-PTF-M6-UFP-00003, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Vessel UFP-VSL-00002B.*

64. 24590-PTF-M6-UFP-00015, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration Utility Services Plant Wash Rack.*

65. 24590-PTF-M6-UFP-00016, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration Reagents & Process Air Bulge.*

66. 24590-PTF-M6-UFP-00026, (HPAV Study Mark-Up P&ID), *PTF Ultrafiltration System Heat Exchangers UFP-HX-00001A/B.*

67. CCN: 119723, August 30, 2005, *Integrated Safety Management Review of Pulse Jet Mixers and Reverse Flow Diverters for Hydrogen in Piping and Ancillary Vessels Generic Solution 1D.*

68. CCN: 119721, August 30, 2005, *RLD-VSL-00008 HPAV Controls.*

69. CCN: 130319, January 18, 2006, *Integrated Safety Management - Hydrogen in Piping and Ancillary Vessel Review of High-Level Waste Pump and Reverse Flow Diverter Discharge Lines.*

70. CCN: 128468, November 9, 2005, *Integrated Safety Management Review of Hydrogen in Pipes and Ancillary Vessels for High-Level Waste Dipped Lines and Vessel Ejectors.*

71. CCN: 128456, January 18, 2006, *Integrated Safety Management - Review of Cooling Water Systems for Potential Accumulation of Hydrogen in Piping and Ancillary Vessels.*

72. CCN: 128455, November 9, 2005, *Integrated Safety Management - Review of High-Level Waste Sampling Systems for Accumulation of Hydrogen in Piping and Ancillary Vessels.*

73. CCN: 130318, January 19, 2006, *Integrated Safety Management - Hydrogen in Piping and Ancillary Vessels Review of the Flushing Water/Reagent and Miscellaneous Water Systems.*

74. CCN: 136179, March 8, 2006, *High Level Waste (HLW) Facility Hydrogen in Piping and Ancillary Vessels (HPAV) Integrated Safety Management (ISM) for Various Issues.*

75. CCN: 111688, July 28, 2005, *Integrated Safety Management for Non-Newtonian Mixing and Hydrogen in Piping and Ancillary Vessels Generic Solutions 1A, 1B, and 1C for PJMs and Reverse Flow Diverter Charge Vessels.*

76. CCN: 111692, August 25, 2005, *Integrated Safety Management for Hydrogen in Piping and Ancillary Vessels Implementation Items 3A- Pump Suction Lines.*

77. CCN: 116905, September 7, 2005, *Application of Hydrogen in Piping and Ancillary Vessels to CNP-VSL-00001.*

78. CCN: 116907, November 3, 2005, *Integrated Safety Management for Hydrogen in Piping and Ancillary Vessels Implementation of Item 9 - Sample Lines in Pretreatment.*

79. CCN:116909, December 21, 2005, *Hydrogen in Pipes and Ancillary Vessels Integrated Safety Management Meeting for Dipped Lines, Vessel Ejectors, System Waste Lines, and Non-Newtonian Pump Suction Lines (General Solutions 4, 5, 2 and 3B) in the Pretreatment Facility.*

80. CCN: 131451, December 21, 2005, *Hydrogen in Pipes and Ancillary Vessels Integrated Safety Management Meeting for Chilled Water Jackets, Water and Reagent Lines, and Pump Seal Reservoirs (Items 6, 7, and 8) in the Pretreatment Facility.*

81. CCN: 132339, January 25, 2006, *Hydrogen in Pipes and Ancillary Vessels Integrated Safety Management Meeting for Dead Legs (Item 10) in the Pretreatment Facility.*

82. CCN: 133308, January 20, 2006, *Hydrogen in Pipes and Ancillary Vessels Integrated Safety Management Meeting for the Ultrafiltration Loop (General Solution 2) in the Pretreatment Facility.*

83. CCN: 133313, January 25, 2006, *Hydrogen in Piping and Ancillary Vessels Integrated Safety Management for Topic 1C Controls.*

84. CCN: 133315, March 7, 2006, *Hydrogen in Piping and Ancillary Vessels Integrated Safety Management Meeting on Pulse Jet Ventilation System Creep and Dipped Capped Lines in Vessels.*

85. CCN: 133316, March 17, 2006, *Hydrogen in Piping and Ancillary Vessels Integrated Safety Management for Topic 1A Stroke Volume.*

86. CCN: 133319, February 3, 2006, *Hydrogen in Piping and Ancillary Vessels Integrated Safety Management Meeting on Carbon Steel Lines in the Pretreatment and High Level Waste Facilities.*

87. CCN: 133334, March 17, 2006, *Hydrogen in Piping and Ancillary Vessels Integrated Safety Management Meeting Revisions of Dead Leg Controls.*

88. CCN: 133542, January 17, 2006, *Basis for Phase II ISM Reviews for Hydrogen in Pipes and Ancillary Vessels (HPAV) Studies.*

89. CCN: 136176, March 9, 2006, *PT/HLW HPAV Control Strategies Standards Identification.*

90. CCN: 136177, March 17, 2006, *Revisions to Hydrogen in Piping and Ancillary Vessels Integrated Safety Management Meeting Results.*

91. 24590-WTP-RPT-M-06-002, Rev. 2, March 17, 2006, *Hydrogen in Piping and Ancillary Vessels – Plant Availability Assessment.*

92. 24590-WTP-GPG-ENG-091, BNI Guide, Rev. 1, January 5, 2006, *Hydrogen Accumulation in Pipes and Ancillary Vessels.*

93. 24590-HLW-M6-HFP-00001, Rev. 1, October 14, 2004, *P&ID - HLW Melter Feed Process System, Melter Feed Preparation Vessel HFP-VSL-00001.*

94. 24590-HLW-M6-HFP-00002, Rev. 2, October 14, 2004, *P&ID - HLW Melter Feed Process System, Melter Feed Vessel HFP-VSL-00002.*

95. 24590-HLW-M6-RLD-00001, Rev. 2, October 14, 2004, *P&ID - HLW Radioactive Liquid Waste Disposal System Active Effluent Collection.*

96. 24590-HLW-M6-RLD-00002, Rev. 2, October 14, 2004, *P&ID - HLW P&ID - HLW Radioactive Liquid Waste Disposal System Plant Wash and Drains Vessel.*

97. 24590-HLW-M6-RLD-00014, Rev. 4, October 14, 2004, *P&ID - HLW Radioactive Liquid Waste Disposal System Offgas Drains Collection Vessel.*

98. 24590-HLW-M6-HDH-00001, Rev. 2, October 14, 2004, *P&ID - HLW Canister Decontamination Handling System.*

99. BNI E-Mail, E. Strieper to R. W. Griffith (ORP), June 6, 2006, "FEP Plant Availability Piping Matrix."

100. CCN: 140963, *Application of PRC-DDT Data to Pipes and Jumpers in PT and HLW Facilities.*

101. CCN: 139899, BNI Draft Memorandum, *Updated Justification of Inputs into PRC-DDT.*

102. BNI E-Mail, E. Strieper to R. W. Griffith (ORP), June 13, 2006, "PTF HPAV Controls."

103. BNI E-Mail, M. Y. Toyooka to R. W. Griffith (ORP), June 9, 2006, "HLW Spare Lines."

104. 24590-PTF-M6C-PSA-00008, Rev. A, December 19, 2005, *PSA Demand for Suction Mode Venting of Pulse Jet Mixers & Charge Vessels.*

105. 24590-PTF-U0C-10-00010, Rev. B, May 9, 2006, *Analysis of PTF Vessel Vent and Overflow Systems During PJM and Sparger Operations using HADCRT Computer Code.*

106. 24590-QL-HC4-W000-00067-02-00001, Rev. 0B, April 20, 2006, *Hanford WTP Hydrogen Bubble in Full Pipe, Calculation C-69089-00-1*, Dominion Engineering, Inc.

107. Dominion Engineering, Inc. Memorandum M-6907-00-19, Rev. 0, December 7, 2005, "Response to DOE Questions Regarding Critical Wave Speed."

108. 24590-QL-HC4-W000-00067-02-00002, Rev. 00B, November 28, 2005, *Effects of Acceleration of Waste Slug Due to Hydrogen Explosion, Calculation C-6908-00-13*, Dominion Engineering, Inc.

109. 24590-WTP-U0C-50-00004. Rev. A, February 6, 2006, BNI Calculation, *Input for the WTP Air Use Diagram.*

110. CCN: 134821, March 16, 2006, BNI Memorandum, "Desktop Instructions for Plant Availability."

111. DNFSB letter, J. Conway to J. H. Roberson (DOE), March 24, 2004, "Research and Development Processes for Addressing Hydrogen Hazards Related to Non-Newtonian High Level Waste."

112. DOE letter, J. H. Roberson to J. Conway (DNFSB), May 21, 2004, "Response to DNFSB Concerns."

113. DOE letter 04-WED-063, R. J. Schepens to J. P. Henschel (BNI), November 22, 2004, "Transmittal of U. S. Department of Energy (DOE), Office of River Protection (ORP) Design Oversight Report on Hydrogen Mitigation and Control Systems, D-04-DESIGN-007."

114. Presentation by Steven M. Barnes, BNI to ORP HPAV Oversight Team, June 5, 2006, *Post DBE UFP-2A/B Pump Supply Line Clearing Tests.*

115. Presentation by Steven M. Barnes, BNI to ORP HPAV Oversight Team, June 5, 2006, *PJM Non-Newtonian "Slug" Internal Mixing Test Results.*

116. 24590-PTF-M6C-PJV-00001, Rev. H, February 27, 2006, *Line Sizing Calculation for Pulse Jet Ventilation System Exhaust Lines.*

Appendix A.
BNI Responses to
Design Oversight Team Questions
For the Design Oversight
of
HPAV Generic Solutions
June 2006

No.	Question	Comment	Response[1]	Status
1	Settling of solids in piping may reduce the effectiveness of water or air purging in removing solids. What are the criteria for the time solids are allowed to settle in piping before the purge must start to ensure the effectiveness of flushing or purging?	For example, how long can the UFP or other high solids system be in a static condition at maximum solids concentration before the water flush or air purge system is ineffective? Was that tested at SRNL?	Tests in non-Newtonian simulant show that solids settling result in an increase in shear stress from a nominal 30 Pa to a maximum of 75 Pa. The change is fairly linear in the first 2 to 2-1/2 days, settling out in 3 to 4 days. The intent for the purge of the UFP suction line is to initiate the blowout in a short period of time after shutdown of the pumps (time will be based on solid settling and the duration of a short term outage, e.g., a short term loss of power). No significant settling is anticipated in this time frame. The air purge is ITS and will, therefore, be available under post-DBE conditions.	**CLOSED**
2	In cases where air purges or water flushes are used to remove waste during normal operation or post-DBE and the system has multiple flow paths, how is it assured that all paths are cleared to the required residual levels?	An example is the tubing in the filters and the split lines for the flow meters in the UFP system. What prevents all of the flow going through one of the two lines and through a small fraction of the tubes?	There is only a single flow meter in the current UFP design. The air purge will not clear all of the tubes in the filters but hydrogen generated in the tubes will migrate to the shell side and into the permeate pulse pots which are periodically purged post-DBE to maintain the hydrogen concentration below flammable limits. The CFD analyses indicate that some of the waste will be removed. However, the CFD analyses also indicate that the purge will not be effective in completely clearing the UFP heat exchanger (spiral path design). Although BNI concludes that the maintenance purge through the system will be effective in maintaining the hydrogen concentration in the heat exchanger below flammable limits, the thickness of the outer shell of the heat exchanger will be increased to prevent failure if a detonation should occur in this component. Such detonation, however, would rupture the barriers between UFP and CHW (the cooling water side). This will contaminate CHW. The contamination will be noted in the radiation detectors positioned in the system. In this event, the heat exchanger would be replaced. The CHW system would have to be de-contaminated. This would have a	**CLOSED**

[1] These responses were obtained during a meeting with cognizant BNI personnel June 9, 2006.

No.	Question	Comment	Response[1]	Status
			significant impact on PTF availability. (see next item for discussion of the impact of HPAV on plant availability).	
3	What is the consequence of an air purge valve in the UFP pump suction line opening during normal operation? What is the calculated risk of this occurring versus the calculated risk of a hydrogen deflagration or detonation?	It is understood that redundant air operated normally closed fail open valves are supplied. Could a motor driven valve operator be used for the normally closed valve instead of the air operated valve to minimize the risk that the valve will fail open during normal operation?	An inadvertent opening of an air purge valve on the suction side of the pump during normal operation would likely cause the pump to fail. The probability of this occurring versus the probability of a hydrogen detonation in this line under static conditions has not been calculated. The Operations Risk Assessment is being updated to include HPAV considerations. This document addresses the safety basis of the plant focusing on the radiological consequences of design basis events. It is based on a best estimate approach. It does not address plant availability. ORP has requested that BNI address the expected frequency and risk of detonation events associated with HPAV. This will require that BNI refine the HPAV evaluations to develop risk assessments of detonations for different conditions and configurations in the plant. This assessment may provide some insight into the relative risk of an air purge valve opening inadvertently and damaging the pump with that of a detonation in that piping under static conditions. This assessment could provide partial bases for establishing the impact of HPAV solutions on the availability of HLW and PTF. **Open Item:** *When they become available, obtain the documents that provide the assessment of the frequency and risk of detonations considering HPAV. Also obtain any additional documentation that assesses the impact of this risk on plant availability.*	**OPEN**

No.	Question	Comment	Response[1]	Status
4	Provide documentation that evaluates the effect of the air purge through the UFP pump suctions into UFP-VSL-0002A/B on the integrity of the vessel.	The flow of air back through the suction line has the potential to erode the bottom of the vessel depending on how far away from the bottom of the tank the line takes suction.	The potential for erosion of the tank shell is negligible. The initial blow of about 1500 cfm lasts for 6 to 8 seconds. The maintenance purge rate is significantly lower and results in a slow bubbling action out of the suction pipe. There is not sufficient energy or extent in the bubbles to damage the vessel shell.	**CLOSED**
5	It is understood that the air purge system for UFP is controlled with plug valves. In the higher pressure sections of the system, it appears that leakage through these valves or inadvertent opening of a valve during normal operation could result in contamination of the PSA; particularly on loss of the PSA system. This would be a major event affecting large portions of the plant. How is this prevented? Supplemental question: Why doesn't the WTP use a block and bleed configuration? This is a typical practice in similar conditions in radiological – chemical facility design.	Normal radiological & chemical design practice would be to provide block and bleed valves between the high pressure fluid stream and the lower pressure areas to capture any leakage through the valve on the high pressure side and prevent contamination of the lower pressure areas. This does not appear to be the practice for WTP. A discussion with John Julyk will be set up to discuss this issue.	The PSA air supply is backed up by the ITS air supply and both pressures are significantly higher than the UFP pressure at these points. Two normally closed isolation valves are also positioned between the UFP system and the PSA/ITS air supply systems. See the next to the last page of this attachment for a discussion on the use of a block and bleed configuration for some areas of concern with double valve isolation in cross-connects between systems of different pressures. In a discussion with J. Julyk 6/12/06, he indicated that BNI normal practice would be to use a block and bleed configuration in this application. The BNI Operations Requirement Document, 24590-WTP-RPT-OP-01-001, as changed by 24590-WTP-ORDCN-OP-05-004, addresses the use of a block and bleed configuration. Bechtel Inc., at the Chief Engineer level, is currently addressing when to use a block and bleed configuration. J. Julyk also indicated that the air purge to the area that includes the heat exchangers and filters may require the use of redundant trains. **Open Item:** *BNI should evaluate changing the design of the PSA purge air supply to the UFP system to incorporate a block and bleed valve configuration.* **Open Item:** *During the above discussions with BNI, the lack of redundancy on the air purge in the mid-section of the UFP was discussed. It was concluded that BNI should considered adding a redundant path to this air purge.*	**OPEN**

No.	Question	Comment	Response[1]	Status
6	Provide the documentation that demonstrates the operability of piping, pipe fittings (e.g., bends, tees) and piping components, (e.g., valves, pumps, instrumentation), under limiting Hydrogen deflagration and detonation conditions.		The DEI calculations applied a load intensification factor (LIF) of 3 to account for the effect of fittings in the pipe stress calculations. DEI also performed a stress analysis on a plug valve that is used frequently in the plant. A BNI consultant (Ed Rodriguez of Los Alamos) is reviewing the DEI valve analyses to establish if additional work or testing is required. The EGRT has raised a similar issue and this is an open item for that group. (See item no. 16) The impact of detonations on piping fittings and components on the safety of the plant will be addressed in the ORA. It was noted that the only valves that have to operate post-DBE are the purge and vent valves on the UFP pulse pots. It is understood that none of the analyses to date have addressed the effect of the high temperature spike attendant to the detonation on the operability of the active components, seals and gaskets and instrumentation. This will need to be evaluated to support establishing the impact of HPAV on plant availability. **Open Item**: *BNI should assess the impact of the temperature spike that occurs during a detonation on post-detonation functionality of the affected active components, seals, gaskets and instrumentation and the impact of repair and replacement efforts on plant availability.*	**OPEN**

No.	Question	Comment	Response[1]	Status
7	Provide bases for statement in Section 2.2.1.2 of 24590-WTP-SE-ENS-05-0041, Rev 0, Page 39 of 90 – "The hydrodynamic loads will not be assumed to occur concurrently with the seismic loads as the ITS SC-I PPJ system will prevent the seismic induced MOB from occurring". Also please provide a brief description of PPJ and its role in HPAV.		The PPJ will have a function to prevent multiple overblows (MOB) in the PJMs during a seismic event. This part of the PPJ has not been designed, so how this will be accomplished is not known at this time (e.g., how will PPJ detect that a seismic event is occurring?). A meeting was held with BNI personnel R. Beck and K. Herman on 6/13/06 in which the functions of the PPJ and its interaction with PCJ were summarized. Discussions during this meeting resolved the Design Oversight Team's question.	**CLOSED**
8	Provide calculations or other documentation supporting use of the Suction Mode Venting and the Scout Mode for preventing significant hydrogen accumulation in PJMs and RFDCVs.	Is there a calculation or other documentation that shows the PJMs and RFDCVs cannot withstand a hydrogen deflagration or detonation? If so, please provide.	Calculation 24590-PTF-M6C-PSA-00008 discusses the functions and air usage during Suction Mode Venting. (A copy of this calculation was received just prior to the meeting.) A reference was provided to the Air Usage Diagram (see item no 33). There is no calculation that evaluates whether a PJM or RFDCV itself can withstand a detonation. SMV has been provided to preclude a detonation in these components. A meeting was held with J. Julyk and G. Kunkler to go over Design Oversight Team questions on calculation 24590-PTF-M6C-PSA-00008. The following open item was developed as a result of that meeting: **Open Item:** *BNI to review the applicability of the current calculated frequency, number of cycles and timing of cycles for a full PJM for a PJM that is not full.*	**OPEN**

No.	Question	Comment	Response[1]	Status
9	Provide description of new valve that replaced deleted spare suction lines (Page 7, Presentation of 6/5/06 – Plant Availability Assessment of PTF and HLW, Ed Strieper)		A picture of this valve was provided to the Design Oversight Team by BNI on 6/9/06 (see Figure A-1). The valve has an extended plug that eliminates the dead leg when the valve is closed. It replaces the cell suction line valves (also see item no. 37).	**CLOSED**
10	Clarify the variations in approaches taken to address HPAV as a function of the time frame in which an excessive hydrogen accumulation is calculated to occur and the effect of these actions on procedural controls and operator actions.	This was covered briefly in pages 7 and 8 of the Plant Availability Assessment of PTF and HLW by Ed Strieper, 6/5/06. The relationship between the times to grow a bubble, (e.g., < 50 hours, >50 hours, 1000 hours, a year) and the corrective actions is not clearly understood.	tBOC = time to grow a bubble to the piping elastic limit using the BOC calculation **If tBOC > 8760 hours,** no action is taken **If 96 hours < tBOC < 1000 hours** and this is a safety case and the strain during detonation > 15% (old criteria), action is required (usually a design feature (e.g., sloped pipe to vent to a lower pressure) or administrative control (e.g., pipe purge or flush)) **If 50 hours < tBOC < 96 hours** and it is a safety case and strain is > 15% (old criteria), operator action cannot be used to preclude detonation; other action (e.g., design feature or engineering solution) is required. **If tBOC < 50 hours,** this is considered an availability issue and an engineering solution is required to preclude the detonation (whether a safety case or not) Review of the piping matrix shows times of 3000 hours and 1000 hours, but not 8760 hours. What is the variation in actions for these several different criteria? This question was closed in meetings with R. Garrett and E. Strieper on 6/12/06 and 6/13/06.	**CLOSED**

No.	Question	Comment	Response[1]	Status
11	Provide documentation that confirms the effectiveness of high point vents on pump suctions under post-DBE conditions (i.e., with PVP above atmospheric pressure) (e.g., pump suction from TCP-VSL-00001).		Calculation 24590-PTF-U0C-10-00010, Analysis of PTF Vessel Vent and Overflow Systems During PJM and Sparger Operations Using HADCRT Computer Code, was provided after the meeting. This calculation, however, does not address this question on high point vent operation on loss of vacuum in the PVP system. **Open Item:** *An analysis is required to show that the high point vents will be operational on loss of the vacuum in the PVP.*	**OPEN**
12	Provide the bases for not requiring redundancy in the air purge system supplied to evacuate the piping and components between the flow control valve and the seismic isolation valve in the UFP system post DBE. Include discussion of the need to add thickness to the heat exchanger shell in this system and not in other components.		This is not a safety issue requiring single failure protection. The only vulnerability in this section of the UFP to failure under hydrogen detonation was the heat exchanger. The outer shell thickness was increased to preclude failure of the shell under calculated hydrogen detonation conditions. (See discussion under item no. 2 above)	**CLOSED**
13	Re: dead legs and blanks, please describe how the dead leg flush operates and how it is effective in removing accumulated hydrogen from dead legs.		The dead legs are flushed through to the destination vessel every time a transfer is made that affects the dead legs. A check is made to ensure that the frequency and time of transfers that affect a set of dead legs is adequate to preclude formation of a BOC in one of the dead legs between flushes. There is no credit taken, however, for frequencies of transfer that may be high enough that dead leg flushes are not required for every dead leg affected by that transfer after every transfer. This approach increases the volume of waste water handled by the facility. A check is being made on the waste water expected to be generated and if it is excessive a manifold by manifold check will be made to determine if the frequency of dead leg flushes can be reduced. (see item no. 17) **Open Item:** *When available, obtain a copy of the evaluation of*	**OPEN**

No.	Question	Comment	Response[1]	Status
			the amount of waste water expected to be generated during dead leg flushes and the conclusions and recommendations that result from that evaluation.	
14	DEI calculation C-6908-00-1 – BOC full pipe: How are materials other than that covered by this calculation (and the similar PRC calculation) handled in the HPAV evaluations The calculation states that the maximum pressure at the discharge on any pump is 172 psia – what is the pressure at the discharge of the UFP recirculating pump over the full concentration campaign? The calculations assume solid end boundaries during the detonation. What is the impact of compressible boundaries on the response?	Compressible boundaries would likely reduce the peak pressure achieved during the detonation, but might induce oscillatory loads that may reverse; adding a fatigue component to the loading that should be confirmed as less limiting than the strain observed in the first quarter cycle of the detonation load. (Note: does DEI C-6908-00-8 cover this case?) Additionally, is the assumption that hydrogen detonation occurs and not a deflagration (that may or may not transition to a detonation) conservative for compressible boundaries (e.g., a less rapid increase in pressure versus time in a deflagration may result in a different response of the waste slug than the impulse that is characteristic of a detonation)?	Hastelloy is the only other material checked. Its properties were compared with 316 stainless and it was determined that if 316 remained in the elastic range the same would be true for Hastelloy. (See Assumption 12 in 24590-WTP-SE-ENS-05-0041, Rev 0 and Section 4.3 of CCN 116909, p. 4 of 29) The UFP pump discharge pressure is currently 114 psig. This system design is not yet complete but a significant increase in this pressure is not anticipated. A DEI calculation addressing a DOE question on critical wave speed was provided to the Team following the meeting. The calculation did not address the question on the potential for oscillating loads if the fluid boundaries are compressible instead of rigid. The Design Oversight Team questioned if, during the detonation, some of the water (e.g., the 100% humidity in the space) were to evaporate due to the high temperature of the detonation and then condense as the pressure returns to normal as the water refills the space left by the detonation, could a "water hammer" event take place. If so, what would be the magnitude of that load compared with the detonation load? BNI is reviewing the loads on the piping supports and displacements of the piping under the PRC detonation loads. It is suspected that these would bound any "water hammer" type loads that would occur post –detonation. However, this has not been considered in the investigation. Calculation C-6908-00-13, Effects of Acceleration of Waste Slug Due to Hydrogen Explosion" was reviewed after the meeting. This calculation examined the long term behavior of a waste slug in a line connected to HLP-VSL-00022. This calculation shows	OPEN

No.	Question	Comment	Response[1]	Status
			that the line is completely evacuated with the slug ejected into the vessel with significant velocity. The calculation does not address the potential impact of the slug or the gas bubble entering the vessel at high velocity. It also does not address the conditions in the pipe on refill. These questions should be addressed (see Open Item for item no. 14). It was noted that a white paper is being prepared addressing HPAV for UFP; the most vulnerable system. This is being prepared to address EGRT open items. **Open Item:** *BNI should address the questions on the potential for oscillatory loads on the piping if there is the potential that the boundaries may not be incompressible (as is assumed in calculations performed to-date), on the impact of waste slug and bubble injection into the vessel and the potential for water hammer type events and loads post-detonation in the pipe.*	
15	Has the configuration management program been updated to include consideration of HPAV for design, procedure and program changes, (e.g., to ensure HPAV considerations are included in the change process including field change requests during construction and testing?)		Update of the configuration management program to address HPAV is on going. This is an EGRT open item to be resolved on the existing schedule for EGRT item closure.	**CLOSED**

No.	Question	Comment	Response[1]	Status
16	Provide schedule for resolution of EGRT open items. Provide any available preliminary information.		A draft of the Fragnet for EGRT open items was received on 6/14/06.	**CLOSED**
17	In the sample HPAV Piping Matrix provided 6/6/06 , FEP Dead Legs – what criteria is used to set the "Controls Selected"?	It is noted that in some cases the time interval required to flush is very short compared with the time to fail elastic, e.g., 100 hours to flush for a time to fail elastic of 7524 hours. Contrast this with another that has a time to fail elastic of 2586 hours and a time to flush of 2500 hours.	The frequency is based on the minimum time required for all of the dead legs in that manifold. In the case cited another dead leg in the manifold had a requirement for flushing within 100 hours. (see item no. 13 above)	**CLOSED**
18	In the sample HPAV Piping Matrix provided 6/6/06, FEP Dead Legs – how are the time intervals for flushing administered?	Are these controlled using the timers that were shown in the controls presentation of 6/5/06? If so, is it reasonable to assume that these timers will operate for 2500 hours without an interruption in power?	Flush requirements are monitored by PCJ (during the discussion with BNI, it was noted that the times for flushing dead legs are based on a tBOC at a pump discharge pressure of 12 atm and an elastic pipe condition). The timers and the control system is backed by a UPS; however, if the power outage on this system is extended beyond the capability of the UPS, flushes will have to be completed on those dead legs that were active prior to the outage to reset the timers. Both the PCJ (under normal conditions) and the PPJ (if the PCJ is not operational) notify the operator when a flush sequence is required. The operator initiates the required flush sequence which is executed by the control system.	**CLOSED**

No.	Question	Comment	Response[1]	Status
19	During/post DBE, what analysis has BNI conducted to determine what specific operator actions are required (and the time required) to mitigate HPAV concerns; in addition to the actions required to maintain the plant in a safe condition?	There are many, many actions required during post DBE (beyond 50 hours) to get the plant in a safe operating mode. The addition of HPAV operations may be overwhelming.	Immediate purges will be done on systems where a transfer was in progress at the time of shutdown. Priority purges will be done first to insure boundary safety, then recovery.	**CLOSED**
20	If there were a bubble of hydrogen in the feed tube to the melter, what investigations has BNI performed to determine what will happen in the melter as the feed (and hydrogen bubble) is pumped to the melter?	There will be combustion or detonation of the hydrogen as it approaches or enters the melter. What damage will occur to the melter or the components in the melter?	BNI has not conducted an analysis of this type of event. The agitators in the feed tank accomplish good mixing and it is believed that there will not be much hydrogen in the feed line.	**CLOSED**
21	What are the effects of hydrogen generation as temperature is increased significantly, as in the melter feed tube?		The agitators in the feed tank accomplish good mixing and it is believed that there will not be much hydrogen in the feed line.	**CLOSED**
22	How will you determine if there is leakage of waste through a shut-off valve into a closed pipe or dead leg?	Leakage back into a dead leg will put you into the same position as before the flush or purge.	All waste lines are flushed with water which should remain in the line. Large leaks would be recognized by an increase in tank fluid level.	**CLOSED**

No.	Question	Comment	Response[1]	Status
23	There have been many spare pipes and RFD's removed from the vessels. What analysis has BNI performed as to loss of future capability?	The plant must operate for 20 years or more. Spares will become very valuable during this period in order to keep operating the plant.	RFD's removed in the PT vessels PWD-VSL-00015, 00016, 00044 are no longer used for sampling. RFD's in the melter feed tank also not planned for sampling. BNI will supply a table showing deleted spares by black cell and hot cell. One of the spare radar tubes is being removed from vessel RLD-VSL-00002 which leaves only one radar tube for tank level measurement, with no apparent means of knowing tank level if there was a failure of the radar tube. All other vessels have redundant radar tubes. This was determined not to be an issue since no realistic failure mechanism for the guide tube could be identified.	**CLOSED**
24	Are the blowers on the vessel vent system, both redundant and on emergency power? What drawing shows this system?		There are two 100% fans, with no diesel backup. With loss of power, there is a passive flow out of the tank. BNI Calculation 24590-PTF-U0C-10-00010, showing the analysis for passive operation of the PTF Vessel Ventilation System was provided to the Design Oversight Team.	**CLOSED**
25	The piping matrix presumably consists of 18,000 pipes, with many pieces of input data. Describe what secondary review, or peer review, was performed by BNI other than the originator. Provide evidence of this review.		When finished, the piping matrix will become a Calc and will be peer reviewed according to BNI engineering procedure 24590-WTP-3DP-G04B-00037.	**CLOSED**
26	During plant operations, describe how an explosion in a pipe or vessel will be detected.		As no need has been identified, there are no plans to detect a detonation in a system that does not have pressure instrumentation.	**CLOSED**
27	Will microphones be placed in all black cells and hot cells? Note which cells will have microphones.		There are no plans to install microphones in either the black cells or hot cells. As noted above, the detection of an explosion or detonation event in a black cell or hot cell has not been determined necessary by BNI's hazard and safety analyses.	**CLOSED**

No.	Question	Comment	Response[1]	Status
28	The "Bubble of Concern" calculation estimates that the gas in a pipe, after an explosion, will reach 3000K. What analysis has be done to estimate damage to non-metallic materials such as seats and seals?		No analyses have been conducted on failure of non-metallic materials. BNI believes that the energy in the gas will be low. This question needs to be resolved at some point in time. (See item no. 6 above)	**CLOSED**
29	What industries has BNI investigated to determine the cause of hydrogen accidents, and the design for safe operation? Please describe what has been found.		An advisory group of 5 industry experts was used. George Antaki coordinated with DWPF on the hydrogen effort that was conducted at Savannah River.	**CLOSED**
30	The waste tank and transfer lines in the Analytical Lab have not been included in the HPAV study. Explain why the Laboratory was not considered, and provide any previous analysis performed on these systems.		The potential for hydrogen in the Analytical lab was evaluated. BNI determined that there would not be a problem because of the low volumes. **Open Item:** *BNI (T. Allen) to supply the ISM meeting notes with the supporting data.*	**OPEN**
31	How many spare lines were deleted (cap welded on nozzle) in PT and HLW? Also identify by hot cell and black cell.		The table for HLW was provided on 6/12, identifying a total of 16 deleted spares. The PTF table was provided to the Design Oversight Team on 6/13.	**CLOSED**
32	In the piping matrix, when a system is deemed to "pass the elastic limit", did the calculation include a load factor for bends and fittings? What load factor was used?		They did include the fittings in the analysis for the elastic limit. The analysis used a load factor of 3.	**CLOSED**

No.	Question	Comment	Response[1]	Status
33	Reference ABAR 05-0041, Section 2.2.1.1. Post DBE, the PJMs will be operated in the first two of three cycles, suction and vent, to clear the headspace. Regarding PJM operation post DBE: • Is the process air system supported by emergency power? • How many PJMs (total) will be expected to operate at the same time? • Provide the calculation that confirms there is adequate air quantity at required pressure to support PJM operation. • What affect do three compressors running have on EDG loading?		In the event of a loss of offsite power, emergency power is available for the ITS air compressors. Two redundant trains, each train consisting of three air compressors support the safety related air supply. Calculation 24590-WTP-U0C-50-00004, Rev A, dated 2/6/06 provides inputs for the WTP Air Usage Diagram. The most recent air usage diagram reviewed (which covers HPAV requirements) indicates that within the first 20 hours following a DBE, all three ITS air compressors are required to run at a total train capacity of almost 83% to supply air to PJM's and vessel spargers. Air demands are preliminary and still must be verified. The 83% air demand is based on the premise that PJM's and other air demands are sequenced. Instantaneous operating PJM's & spargers post DBE will overload the air compressors. **Open Item:** *A control logic design must still be developed for air usage sequencing.* **Open Item:** *The affect of three compressor operation on the EDG loading needs to be demonstrated.*	**OPEN**

No.	Question	Comment	Response[1]	Status
34	Refer to ABAR 05-0041, Section 2.5.1.1 (Generic Solution 3a, SFC applied). The ABAR states that the vent valves will open when there is no flow in the pump suction line. It also states that the pump status will be interlocked with the opening of the vent valves. • Is the interlock between the pump and the vent valves only, or is there flow measurement in the suction line? • What is the potential for full or partial blockage in the suction line? • Are the pump/vent valve interlocks designed to single failure criteria? (independent reliable power supply)		Generic Solution 3a covers Newtonian fluids; blockage is not a problem. Generic solution 3b covering non-Newtonian fluids is applied to a 4 inch suction line with little chance of blockage.	**CLOSED**

No.	Question	Comment	Response[1]	Status
35	Refer to Generic Solution 3a, 3b, 2b (suction venting). During normal pump operation, the two inch vent line may be filled with stagnant waste to a level that almost matches the level in the tank. • Especially for the case of non-Newtonian waste with up to 20% solids that requires constant agitation (and even lesser solids content), will this filled stagnant small bore pipe restrict venting?		BNI is aware of this condition. A demineralized water flushing connection is provided to flush out the suction vent line. **Open Item:** *Time and frequency of the flush has yet to be determined.*	**OPEN**
36	Provide analysis or test results that demonstrates ITS valves and instruments will remain operable post hydrogen explosion. Please address impact on seals, packing, etc, besides the impact on pressure retaining components. DEI calculation C-6908-00-1 "Hydrogen Bubble in Full Pipe" doesn't address valves and instruments.		See item no. 6 above.	**CLOSED**

No.	Question	Comment	Response[1]	Status
37	Redlined note 29 on drawing 24590-PTF-M6-HLP-00001 states that a valve will be added that seals flush against the suction pipe. Provide details of valve type and installation details.		A picture of the plug valve was provided (see Figure A-1). The valve has an extended plug that eliminates the dead leg when the valve is closed.	**CLOSED**
38	In the piping matrix comments/open issues column, many entries state "Jumpers are assumed to be as strong as the adjacent piping". What is the basis for this statement?	Piping is not the most limiting element of the assembly. Gaskets, seals, bolting, etc must be considered.	BNI based the assertion that the jumpers are as strong as the piping in which they are located on the fact that the piping and jumper have the same schedule. In addition, BNI was only concerned about the bulk confinement of the waste (e.g., at the seal joint). BNI stated that only bulk confinement is required. Small leakage from seals and gaskets was considered in the spray leak DBE analysis.	**CLOSED**
39	Changes are being performed to increase resistance to explosions, such as increased UFP heat exchanger shell thickness. This is a spiral design heat exchanger. Has the internal process/chilled water interface been evaluated for pressure integrity following an explosion? Failure of this boundary could contaminate the plant chilled water system.	The credited safety function of the safety Significant UFP heat exchanger is to provide primary confinement of radioactive waste that, if released to the chilled water system, could result in radiation dose in excess of the radiological exposure standards.	There are radiation monitors in the chilled water system to isolate the chilled water from the heat exchanger and divert the contaminated water to a safe place precluding circulating contaminated water to the BOF.	**CLOSED**

No.	Question	Comment	Response[1]	Status
40	It was determined that additional controls were not required if times to achieve 8% LFL are at least 1000 hours. Provide the basis for using 8% criteria.		The basis for the 8 vol. % hydrogen concentration acceptance criterion is documented in a DEI calculation that showed no damage to equipment for an explosion at this concentration (i.e., design pressures exceed explosion pressures). However, BNI will control to 4 vol. % hydrogen for accident conditions and 1 vol. % hydrogen during normal plant operations. The 8 vol. % was only used to determine the need for ITS controls.	**CLOSED**
41	During Suction Mode Venting, what prevents waste from being drawn up the pipe to the JPP? Could waste in contact with the eductor compromise performance of the JPP?		Barometric head will make it impossible to draw waste to the level of the JPP.	**CLOSED**
42	As a result of HPAV generic solutions involving PJM operation, has the duty time for PJM operation increased? Has the potential for PJM reduced life due to increased cycles been considered?		The PJM's are qualified for a 40 year continuous duty life. Air supply valves located in racks are accessible for maintenance, if required.	**CLOSED**

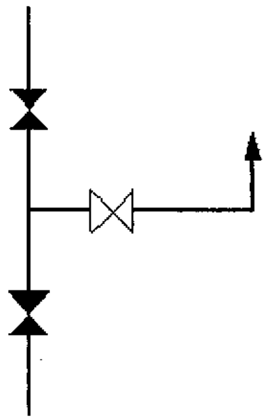
APPLICATION OF BLOCK AND BLEED CONFIGURATION

A block and bleed configuration is typically applied in the cross-connect between two systems that are at different pressures under normal operating conditions to prevent flow from one system to the other if the pressure differential were to reverse under abnormal operating or accident conditions and isolation valves were to leak. This configuration has several advantages:

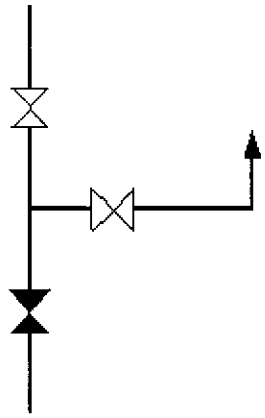
- Ensures that leakage through either of the isolation valves in the cross-connect will be vented and cannot enter the other system.
- Ensures that pressure will not build up in the volume between the isolation valves if both are closed. The build up of pressure could have several consequences:
  - In the case of HPAV it would increase the initial pressure for detonation and therefore the piping stress and loads on the isolation valves on detonation.
  - It could increase the loads on the valves to the extent they bind and will not open.
  - Extreme build up of pressure, (e.g., leakage into the area under cold conditions and then heat up of the piping under higher ambient conditions) could fail the piping or connections to the valves.
- Prevents accumulation of hydrogen in the cross-connect (e.g., if the vent if properly configured to connect with a higher elevation) during the periods when both isolation valves are shut; precluding a detonation in the cross-connect.

Without the vent, these conditions need to be considered and resolved in the cross-connect between two shut isolation valves.

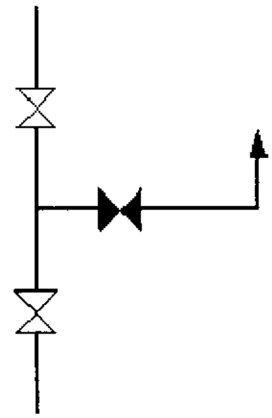
The following illustrates a possible operating sequence for the block and bleed configuration. The assumption is that the upper system is normally at the higher pressure.



Configuration 1 – Normal operation; cross connected systems are isolated from each other; cross connect vented.



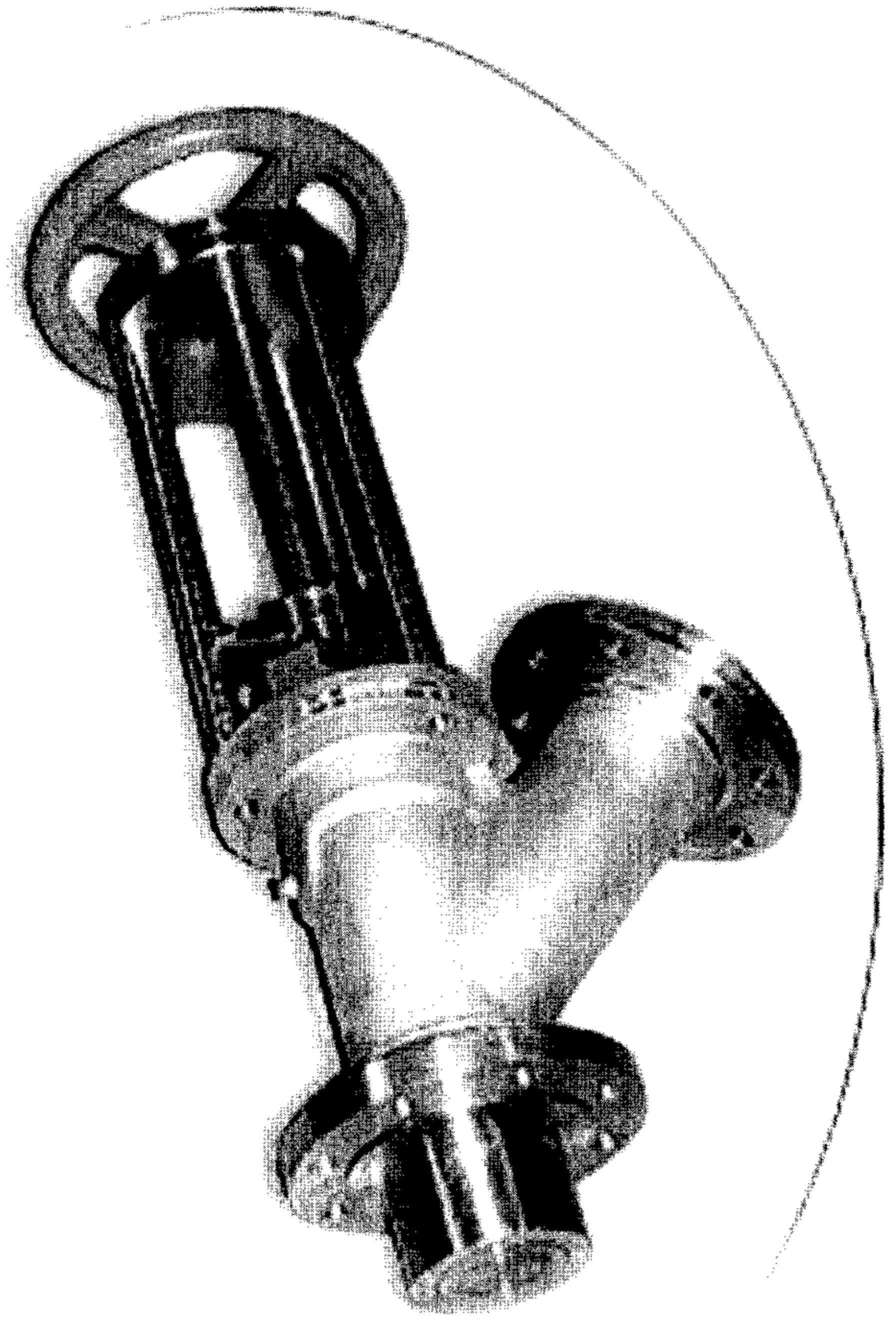
Configuration 2 – Prepare to purge; high pressure side opens to clear vent and cross connect from any leakage.



Configuration 3 –Vent closed; systems cross-connected.

Block and bleed valves are available that provide these functions in a single assembly. These are commonly used in petrochemical and radiological applications.

Figure A-1. WTP Plug Valve Redesigned to Eliminate Dead Leg



Appendix B.
Resolution of the Lines of Inquiry for the Design Oversight of HPAV Generic Solutions
June 2006

LOI#	Line of Inquiry	Conclusion
Scope of HPAV Generic Solutions		
1	Do the ten generic HPAV solutions and their derivatives encompass all potential build-ups of flammable gas in WTP pipes and auxiliary vessels? If not, are the ten generic solutions intended to provide adequate control strategies for all potential build-ups of flammable gas in WTP pipes and auxiliary vessels?	The objective of the HPAV program was to address the potential for build up of flammable gas in all WTP pipes and ancillary vessels. In this regard, the program evaluated all of the piping and ancillary vessels in Pre-treatment (PTF) and High Level Waste (HLW) facilities. These are the only facilities that are judged to contain waste with sufficient hydrogen generation rates to present a problem. Statistically, 9924 lines and vessels were evaluated in PTF and 4432 in HLW. 5686 lines and vessels in PTF were judged to have no HPAV hazard, 3567 in HLW. The remainder had varying levels of potential hazard based on the specific hydrogen generation rate for the waste handled by those lines and/or vessels, the safety and availability significance of the affected line and/or vessel and the capability of the line or vessel to withstand a hydrogen detonation without structural failure. Approximately 1700 lines and vessels in PTF and 55 in HLW required some form of engineered or design feature and/or operator action to preclude accumulation of hydrogen and a potential detonation. The ten generic HPAV solutions and their derivatives represent the engineered features. Design features include line slope and pipe schedule. Operator actions include initiation of transfers and line flushes within specified intervals. The remaining lines were judged capable of withstanding a detonation without failure. In summary the ten generic solutions and their derivatives do not encompass all potential build up of flammable gas in WTP, but when combined with design features, operational constraints and piping structural capabilities all potential build-ups in WTP pipes and auxiliary vessels are addressed.

LOI#	Line of Inquiry	Conclusion
	Design Acceptability/Viability/Effectiveness	
2	How is Pulse Jet Mixer (PJM)/reverse flow diverter (RFD) venting performed?	
	a. Is the intent to pulse the flammable gas out of the PJM/RFD using the normal drive cycle from the PJM rack? If so, how is complete flammable gas venting assured and how is a vessel overblow event avoided?	The concentration of hydrogen in the PJMs and RFDCVs is limited to 1% during normal operation. The normal operating modes of the pulse jet mixers and RFDs are sufficient to maintain this level. Post-DBE, or in the event a PJM is not operated within the time required to ensure a bubble of concern is not generated, Suction Mode Venting (SMV) logic (part of HPAV generic solutions 1.a, 1.b, and 1.c) is initiated. SMV involves completing several cycles of the suction side of the fluidics circuit to evacuate the PJM headspace of hydrogen, venting the hydrogen to the Pulsed Jet Vent (PJV) system. Under normal operation the maximum permitted concentration is 1%; under post-DBE conditions 4%. Calculation 24590-PTF-M6C-PSA-00008, Rev A provides the air consumption required to complete SMV and the number of cycles required to reduce hydrogen concentrations in these vessels from 4% to 0.01% for hydrogen generation rates assuming full PJMs. (Open Item No. 2 addresses the operation of SMV when the vessel level is below the top of the PJM and the PJM is not full.) In non-Newtonian vessels, Scout Mode operation of the PJMs will be used to remove hydrogen from the PJM headspace by running the PJMs at 85% stroke. In this mode, each PJM within the vessel is driven to the 85% empty level (35% further than the normal 50% level) in series following each normal 50% pulse cycle. This ensures that new waste is mixed in with the waste remaining after the normal cycles and any retained hydrogen is vented from the PJM to the PJV system. An overblow is prevented by only stroking one PJM at a time and limiting the stroke to 85%.
	b. If not, is the intent to vent the flammable gas into the pulse jet vent (PJV) header? If so, is there any potential to build-up flammable gas in the PJV system?	In the suction mode, the gases evacuated from the PJMs are vented to the pulse jet header. PJV is normally maintained at a small vacuum and vented through the stack. Under loss of power conditions, flow through the PJV system is maintained by the mixing air provided to the pulse jet mixers by the air compressors on emergency electric power. (BNI calculation 24590-PTF-M6C-PJV-00001 contains the supporting analysis.) Normal PJV flow and the PJM drive and suction flows are sufficient to dilute any flammable gases in the system as they flow out the stack.

LOI#	Line of Inquiry	Conclusion
	c. If new vent piping is planned, how is the operability of the PJMs/RFDs not compromised?	No new vent piping is planned.
	Please be clear in your response as to which actions are automatic, which are remote operator, and which are local manual operator actions.	The normal cyclic operation of the PJMs is automated. RFDs are operator initiated. In Newtonian vessels, each PJM and RFD has a maximum period over which it may sit idle, (i.e., not being used). If that period is exceeded for a PJM, PCJ (or if PCJ is inactive PPJ) will initiate SMV for that PJM. Under normal operating conditions, the SMV initiation frequency and cycles will be based on a maximum hydrogen concentration of 1%. Under post-DBE conditions they will be based on 4%. In non-Newtonian vessels, the frequency at which the Scout Mode is initiated depends on the vessel. PCJ (or PPJ, if PCJ is inactive) will initiate Scout Mode for the PJMs depending on the required frequency for that vessel. Tables 2 and 3 (page 35 of 36) of 24590-WTP-RPT-M-06-002, Rev 0, HPAV – Plant Availability Assessment, lists the requirements for Newtonian and Non-Newtonian Vessels, respectively.
3	For non-Newtonian vessels/fluids, how is the venting performed to ensure that flammable gas captured in the fluid/waste matrix within the PJM is released as well?	In normal operation, before the drive stroke is initiated, the PJM is filled by initiating the suction mode until the pressure gauges in the fluidic control rack detect the pressure pulse as the waste enters the pulse tubes. This ensures complete evacuation of the PJM headspace prior to the drive stroke (50%) used to drive the fluid into the vessel to promote mixing and release of hydrogen from the fluid matrix. On a periodic basis, each PJM will be operated in the Scout Mode. Scout Mode operation involves driving the fluid column in the PJM through an 85% stroke, which has been shown by testing to adequately mix the residual fluid in the PJM with fluid from the vessel and release any retained hydrogen to either the vessel or PJM headspace. Normal operation of the PJV or PVP/PVV systems will remain the hydrogen from the PJM or vessel headspace.

LOI#	Line of Inquiry	Conclusion
4	What design or operating characteristics exist relative to the jet pump pairs that precludes flammable gas accumulation from being an issue in the piping between the jet pump pair and the air rack isolation valves?	During normal operation of the PJMs, the JPP piping is swept clear with fresh air during the drive mode of operation. These volumes are also evacuated during Suction Mode Venting.
5	How is flammable gas venting accomplished for PJMs/piping between the PJMs and the jet pump pair if the PJM racks are failed due to a DBE?	Generic solutions 1.b and 1.c provide cross-connects between the separated racks and redundant suction side valving that allows operation of Suction Mode Venting for all PJMs in both vessels from one rack.
6	a. How will the design ensure that reboiler and evaporator drain lines adequately drain the waste material to a downstream location?	These drains are only used in the event the reboiler or evaporator has to be taken out of service for major repair or replacement. In that event, jumpers are used to drain the component to vessel PWD-VSL-00033.
	b. Why isn't the flammable gas accumulation concern extended to the drain system with this approach?	These drain lines are sloped to vent any generated gases up through the reboiler and into the evaporator head space which is purged and vented.
7	How is compressed air purging effective in removing non-Newtonian waste from pump suction piping?	To be effective, the air purge in the pump suction lines (e.g., UFP) must remove at least 70% of the waste from these lines. A full scale mockup of the UFP pump suction line was constructed at SRNL and tests were conducted over a range of air pressures and flow rates to establish the required conditions to meet this requirement. This test-series concluded: The suction line can be emptied with a 30 psig purge within 10 seconds at a nominal rate of 1500 scfm Both steady and transient purging modes were successful in removing about 85% of the high shear simulant (~25Pa, ~25cP) The air purge was successful in removing more than 90% of diluted simulant (9Pa, 21cP) See presentation material, "Post DBE UFP-2A/B pump Supply Line Clearing Tests", Steven M. Barnes, Presented to ORP HPAV Oversight Team, June 5, 2006

LOI#	Line of Inquiry	Conclusion
		These tests were used to validate CFD models that were then used to confirm the effectiveness of the air purges in the other suction lines.
8	Are there potential flammable gas accumulation high points in the piping for Cesium Ion Exchange Process System and Ultrafiltration Process System (UFP) recirculation and, if so, how does BNI plan on periodically venting this flammable gas?	The Cesium Ion Exchange columns have a Safety Significant nitrogen purge system to maintain the column headspace inert and to vent flammable gases from the columns. Under normal operation, the UFP recirculation returns to UFP-VSL-00002A/B which is purged and vented; maintained at <1% hydrogen concentration. On loss of power or DBE, the system is isolated and air purges (seismic and redundant) evacuate the waste from the suction piping up to the seismic isolation valve and between the flow control valve and the return to the vessels. There is also an air purge that nominally will evacuate the waste between the flow control valve and the seismic isolation valve. This system is not currently redundant. The ORP Design Oversight Team recommends re-evaluating whether this system should be seismic and redundant to prevent a possible detonation in this area under static conditions and consequential loss of the heat exchanger, filters and pumps. Although BNI has concluded such a detonation would not be a safety issue, the recovery from such an event would have significant impact on PTF availability.
9	What provisions are provided to clear potential plugs in pulse tubes, particularly in non-Newtonian vessels?	These pulse tubes are operated frequently and are subject to significant air purges during the suction and drive modes in the Scout Mode of operation. The JPPs are located well above the maximum operating level of the vessel (well in excess of the height equivalent to the barometric pressure of the site) so waste cannot be pulled up into the JPPs during the suction mode of operation.
10	a. What is the drain installation and flowpath for Waste Feed Evaporation Process System and Cesium Nitric Acid Recovery Process System evaporators and piping header dead legs?	See the resolution of LOI no. 6 above.

LOI#	Line of Inquiry	Conclusion
	b. Do design documents correctly implement the design requirements for the important to safety flush water system?	There is no ITS flush water system. Line and dead leg flushes are only considered a preventative measure if the time to grow a bubble of concern is longer than 50 hours. Based on area history and provisions for backup power, a loss of power (that would prevent initiation of flushing) has an annual probability of occurrence of 10^{-5}. Other measures (e.g., ITS air purge on the UFP lines) is required if the time to grow the BOC is less than 96 hours (if safety concern) or 50 hours if an availability concern.
11	There are varieties of unverified assumptions in the hydrogen generation rate calculation. Some of the more significant of these were described in the January 12, 2006, Design Oversight Report (05-WED-054). What is the sensitivity of the proposed design to changes in the assumptions questioned in this report; e.g. different presence of organics, sucrose, etc.?	The evaluation of HPAV in PTF and HLW has been focused on safety. The extent of preventive and mitigative measures taken to address HPAV depend on the potential threat to the public, co-located worker and the facility worker and the time it takes to get to an accumulation of hydrogen that could detonate (time to grow a bubble of concern). The hydrogen generation rates are based on bounding values for the waste in the vessel (for pipes and vessels that contain waste) and on bounding radiolysis rates in non-waste containing systems (e.g., cooling water systems). The generic solutions, operational constraints and design features are designed assuming a probability of 1.0 for hydrogen detonation if a bubble of concern is generated in a certain time frame (e.g., tBOC< 1000 hours) in a pipe or ancillary vessel. Accordingly, the extent or characteristics of these measures are affected by the conservatism in the assumed hydrogen generation rates in the HGR/Time to LFL calculation. However, the Design Oversight Team did not identify any HPAV generic solution that would require additional control features or could become unnecessary due to refinements in the HGR/Time to LFL calculation assumptions. In the availability assessment, calculated times to grow a BOC have reduced some of the conservatisms (e.g., actual maximum operating temperatures have been assumed rather than bounding temperatures, hydrogen solubility has been assumed in some cases). Thus, it is not expected that refinement or changes to the assumptions in the HGR/Time to LFL calculation would have any significant impact to HPAV generic solutions implemented or revised for plant availability considerations.

LOI#	Line of Inquiry	Conclusion
12	BNI has proposed to exclude portions of structures, systems, and components (SSC) from concern based on slow accumulation of flammable gas, strength of SSC material to withstand explosions, and calculations of the strength of the explosion. These proposals are under review by ORP. What is the sensitivity of the proposed design to changes in these criteria; e.g. different acceptable strain levels, different acceptable time criteria, or different calculated strength of explosions.	The original safety basis assessment was based on an allowable of 15% strain for the pressure pulse resulting from a detonation at stoichiometric conditions of hydrogen and nitrous oxide for waste streams and hydrogen and oxygen for water streams. Subsequent to that assessment, ORP changed the criteria to only permit calculated piping stresses up to the elastic limit (0.2% strain) of the material. BNI completed a re-analysis of the piping and vessels in PTF and HLW to the revised criteria and also applied actual maximum operating initial pressures, rather than bounding initial pressures. Based on preliminary results received by the Design Oversight Team in meetings with BNI personnel on June 6, 9 and 12, 2006, 409 lines in PTF and 77 lines in HLW required re-evaluation. Of these, ~222 lines in PTF required addition of engineered or design features (e.g., reliance on line slope) and 19 pipe sections required increases in pipe schedule. Approximately 240 feet of pipe that has already been installed will have to be replaced. In HLW, ~49 areas required the addition of engineered or design features and two pipe schedules were increased.
13	What is the intended design change/HPAV generic solution for capped spare dipped lines having the potential to trap flammable gas? Is this design change effective in preventing the accumulation of flammable gas in these lines?	In vessels that have already been procured, the spare dipped lines are cut off inside and out and the nozzle is capped. Since the capped line will only be exposed to the vessel head space that has an active purge and vent system to maintain hydrogen concentration below 1%, this is an effective means of preventing the accumulation of flammable gas in these lines. The ORP Design Oversight Team considered whether the removal of these spare lines presented a potential availability issue in the future by limiting the flexibility the plant would have in addressing loss of an original line. The conclusion was that the number of lines to be removed is minimal and should not present a long-term problem.
14	What is the technical basis for excluding components (e.g., thermowells) from requiring HPAV generic controls?	The cavity of the thermowell is not exposed to flammable gases.

LOI#	Line of Inquiry	Conclusion
		Operational Implications
15	How do the cross-ties between the 50/50 split racks impact the operability of the PJMs? Is the purpose of the cross-tie valves to preclude any such impact?	The addition of the cross ties permits the initiation of Suction Mode Venting for all PJMs in the two vessels supplied by the racks from either rack. This adds redundancy and separation for this function; improving its overall reliability.
16	What impacts to constructability, operability, reliability, accessibility, maintainability, and inspectability (CORAMI) occur due to implementation of the HPAV changes?	Based on the information available to the date of this report, it appears that there are several thousand measures that have been or will be taken to address the HPAV issue. These measures include reliance on design features, (e.g., maintaining slopes in pipes to prevent accumulation of hydrogen to a detonable level and schedule of pipes to ensure that the pipes can withstand a detonation), adding operational constraints, (e.g., requiring completion of transfers and initiation of flushes within specific time frames), and active engineered features, (e.g., air purges of pump suction lines in systems handling non-Newtonian fluids, adding redundancy and additional cycling logic to operation of PJMs) to prevent the accumulation of hydrogen to detonable levels. Many of these measures result from the safety case and are currently slated to become a part of the Technical Safety Requirements for the plant; therefore, special control and surveillance will requirement development and implementation during the completion of design, construction, testing and operation of the plant. It is uncertain at this time how many of these items fall into each category. Matrices that define the measures taken for each pipe and vessel for the safety case and for availability have not been completed and reconciled. However, as noted, it appears that there will be in the order of several thousand items. This presents a significant configuration management (CM) burden and adds many operational constraints on the operators and operation of the plant. Many of these items are monitored and administered by the Programmable Protection (PPJ, ITS) and Programmable Control (PCJ, non-ITS) systems, (e.g., timing of transfers and flushes, implementation of Suction Mode Venting for PJMs); adding significant complication to developing, verifying and validating the efficacy of the logic supporting these controls. To promote adequate control of these items, BNI should ensure that the HPAV items are fully accounted in its configuration management program. These elements of the program will also need to be transferred to the CM program for operation of the plant.

LOI#	Line of Inquiry	Conclusion
		In developing these measures for the safety case, BNI has applied conservative assumptions in each phase of the evaluations. Accordingly, there is considerable margin between calculated conditions for HPAV and the actual conditions expected during operation of the plant. The assessments of the impact of HPAV on availability should provide a realistic estimate of the expected HPAV risk, (e.g., annual probability of a detonation that affects system operation) since it should be based on expected operating conditions in the plant and less conservative assumptions on hydrogen generation, accumulation, deflagration, detonation and impact on the plant components. These assessments may, therefore, provide a basis for re-evaluating the necessary level of control required for certain of the HPAV measures, (e.g., surveillance of pipe slopes post-construction) to reduce the CM burden during operation. BNI should also consider adding provisions in the plant design to monitor actual hydrogen generation rates in key locations, (e.g., in non-Newtonian vessels) during plant operation. These measurements over time, combined with the availability assessments, may also permit re-evaluating the specific requirements for control and implementation of the operational constraints and engineered features.
17	What is the impact to total operating efficiency from implementation of the HPAV changes? To what degree, if any, do HPAV changes impact facility throughput?	The BNI evaluations on plant availability to the date of this report are not complete. BNI has indicated that hydrogen detonations may occur during normal operation for bubble sizes less than the calculated bubbles of concern. It is uncertain what the energy potential is in these expected detonations. These detonations are not of concern for the safety case since they are bounded by the bubbles of concern. However, BNI has not determined if components in the affected systems would be functional after exposure to the high temperature spike associated with the detonation, (e.g., failure of valves, pumps, seals, gaskets, instrumentation). These components may have to be replaced before resumption of operation after the detonation. (Note: DEI has evaluated a limited set of components for the pressure pulse, but not for the temperature spike associated with the detonation.) Accordingly, completion of this evaluation should consider completing the following: • Developing the expected frequency and impact of potential hydrogen detonations on the functionality of affected systems. This will require developing for the PTF and HLW systems: – Realistic assessments of the potential for hydrogen generation and accumulation, conditions for deflagration and transition to detonation,

LOI#	Line of Inquiry	Conclusion
		– Evaluation of the impact of a deflagration and/or detonation on the functionality of components in the affected systems, and – Establishing the time to repair, if damage is anticipated. • Combining this data with similar data on the reliability of the engineered features added to the plant to establish the effect of HPAV on the availability of PTF and HLW. • The results of these evaluations should then be added into the current availability assessments for WTP to understand the full impact of HPAV on plant throughput (Contract requirement C-7(b)).
18	Explain how BNI has or will determine the time and the time sequence of operator actions required for the selected preventive and mitigative control strategies. How much operator time per shift is estimated to be required to perform these manipulations?	The HPAV safety case mitigative strategies are essentially passive. They are based on demonstrating through calculations using conservative assumptions on hydrogen generation rate, the pressure pulse attendant to a hydrogen detonation at stoichiometric conditions and pipe strength that the pipe or vessel can survive a hydrogen detonation without loss of structural integrity (e.g., current criteria is that the stress in the pipe cannot exceed the elastic limit). The safety case preventive strategies are generally automatically initiated. These include: initiation of Suction Mode Venting of a PJM that has been idle for a time in which a flammable concentration of hydrogen may have accumulated; initiation of the Scout Mode of PJM operation in non-Newtonian vessels to ensure thorough mixing of the waste in the PJMs, and initiation of high point vents or air purges in the suction lines of pumps and in the UFP high pressure side post-DBE. The opening of the high point vents and the air purges of suction lines will also occur whenever these pumps are shutdown. These vents and purges are controlled by the PCJ or PPJ systems and is expected to require, at most, push-button or computer screen initiation and monitoring by control room operators. There are several other availability-oriented preventive flushing sequences and timing of transfers that are operator-initiated. The PCJ (and, if the PCJ is not operating, the PPJ) will alert the operator that a transfer is needed or a flush sequence initiated. The operator then initiates the transfer or sequence from the control screen. The time required for these actions and the potential burden on the operator to remain cognizant of the actions that have been taken by the PCJ and PPJ and the state of the plant has not yet been fully developed by BNI.

LOI#	Line of Inquiry	Conclusion
19	Which portions of the SSCs potentially affected by HPAV will be inspected, during operations, for damage due to flammable gas detonation or deflagration? How frequently will these inspections occur?	Unless the detonation results in major damage to the system, it is very unlikely that the deflagration or dctonation would be detected. At this time, BNI has not identified any need for post-deflagration/detonation inspections.
20	Which portions of the SSCs potentially affected by HPAV will not be inspected, during operations, for damage due to flammable gas detonation or deflagration? What is the basis for the determination that these portions will not be inspected?	See response to LOI no. 19 above.
21	What is the intended operating approach for the proposed engineering controls for each of the HPAV flammable gas generic solutions (e.g., how often will the air purge or wash be performed, what will direct the operators to perform these operations, how will successful completion be determined)?	The air purges of the suction lines of high solids contents systems will be initiated whenever the pump is shutdown and the seismic isolation valve is closed; this includes post-DBE. The air purges on the rest of the UFP system are initiated post-DBE or if the system cannot be normally flushed due to an abnormal operating condition. The timing of the availability flushes are based on the minimum time to generate a bubble of concern in the piping affected by that flush (e.g., in a manifold that has several transfer paths, the maximum time between flushes is based on the minimum time to generate a bubble of concern in lines connected to that manifold).

LOI#	Line of Inquiry	Conclusion
		Safety/Authorization Basis
22	What additional controls were identified to ensure waste in Radioactive Liquid Waste Disposal System Vessel 008 remains below 2 wt. % solids over and above existing controls to limit solids loading?	This is covered in the ABAR approved by ORP to implement these controls in vessel RLD-VSL-00008. The tank is filled with water to a level required to limit the net solids content to 2 wt. % based on the solids content of the source vessel.
23	a. Explain which preventive and mitigative control strategies are automatic, and require no operator action to occur. Describe those strategies, including parameters to be sensed, and actuation logic.	See response to LOI nos. 18 and 21 above. The majority of the active controls are time based (e.g., the time since the last operation of a PJM, the time from the last transfer or flush of the line) or on sensing of a DBE (e.g., seismic event).
	b. Detail which, if any, of these automatic actions meet the single failure criterion. (Do not include non-redundant safety class systems using the relaxed single failure criterion currently under review by ORP.)	The ITS PJM fluidic racks are seismic and meet single failure criteria. These racks implement Suction Mode Venting and the Scout Mode of PJM operation. The air purges meet single failure criteria through the use of redundant paths. (Note: an Open Item identified by the Design Oversight Team is the need for BNI to evaluate adding a redundant air purge path to the mid-path purge in UFP).
24	Explain which preventive and mitigative control strategies require some operator actions. Describe those actions, and where they must be performed.	The preventative flushes of dead legs or the initiation of transfers are the only required operator actions. The number of these required flushes has not yet been established.

LOI#	Line of Inquiry	Conclusion
25	Explain why the air system has sufficient capacity, and specifically what assumptions regarding operator performance are made to ensure the available capacity will not be exceeded. Please include a discussion of how different mixing and purging requirements will be coordinated to ensure the air system is not overloaded. Discuss how periodic and unscheduled repair maintenance will be accommodated.	The Suction Mode Venting and Scout Mode operation of the PJMs and RFDCVs add loads to the ITS compressors. The impact of this additional load on the capability of these compressors to meet their safety functions has not yet been established. Additional analysis will need to be completed by BNI and have been identified as an Open Item from this Design Oversight for submittal to ORP when complete.
26	Describe the bounding case flammable gas hazard: Assuming no operator action, an initiating event such as a loss of offsite power, or a design basis earthquake, and a single failure of an active system, what will occur in the facility, over time? Do not stop this discussion with the first explosion of flammable gas, but explain when subsequent explosions would be expected to occur.	Bounding conditions on hydrogen generation rate have been used in the HPAV calculations. It is also assumed that if a bubble is formed at a flammable concentration a detonation will occur and the pulse magnitude is based on stoichiometric hydrogen and oxidant conditions. A generated hydrogen bubble of concern (BOC) is one that, if detonated, would produce stress at the elastic limit of the pipe and vessel material. Preventive and mitigative actions are required if the time to generate a bubble of concern is less than 1000 hours The need for automatic action depends on the severity class of a potential failure in the affected system and the time to a BOC. If the failure represents an SL-1 consequence to the public, engineered preventive action that meets single failure criteria is required. If the consequence to the co-located worker (CLW) is SL-1 and is moderate to low (SL-2 or lower) to the public and the time to BOC is <96 hours, engineered protective features are required. If the time to BOC is <12 hours, engineered features that meet the single failure criteria are required. If the time to BOC is > 96 hours, then operator action can be credited with performing the safety function in lieu of engineering protective features. These are the bounding safety case conditions. There has been no effort to date to evaluate the probability of a detonation in the facility or to establish a safety or availability risk to the facility from a hydrogen detonation. In addition, there has been no assessment reported to date of what occurs in the systems post-detonation or if there can be multiple detonations.

LOI#	Line of Inquiry	Conclusion
		The evaluations of the effects of potential hydrogen detonations on piping and vessel integrity have focused on the response to the pressure spike attendant to the detonation. A DEI calculation does examine the longer term response of the fluid slug in the pipe after the initial detonation pressure spike has dissipated, but the deflagration pressure is still present in the pipe. This calculation shows that in pump suction piping the waste slug is fully ejected from the pipe into the vessel. The consequence of this has not been further developed or evaluated. The following should be considered: The impact of the ejected waste slug on the integrity of the vessel and vessel internals (the DEI calculation makes a qualitative judgment that the vessel integrity is not affected, but does not substantiate it nor look at other effects, (e.g., the effect of the waste slug and the gas bubble on internals)) The pressure response and loading in the pipe as it refills with waste after the waste slug is ejected. In this regard, the following effects should be considered: - Oscillatory loads (that may present fatigue concerns) as the waste refills the pipe against any remaining gases, and/or - The potential for "water hammer" as the waste re-enters the pipe, if a void has been generated either due to condensation of water or water vapor that was evaporated by the temperature spike attendant to the detonation or condensation of the detonated gases.
27	Why is it acceptable to allow an accumulation of flammable gas (8 vol %) greater than the lower flammability limit when evaluating the acceptability of an HPAV generic solution?	This level was only used for evaluation purposes (e.g., an action needed to be taken if the calculations indicated that an 8 vol% of hydrogen could accumulate in 1000 hours – equivalent to 4 vol% in 500 hours). The intent is to ensure that hydrogen levels in open spaces, (e.g., vessel heads, PJMs, RFDCVs) are maintained at less then 1 vol% hydrogen during normal operation and < 4vol% post-DBE.
28	Where do the siphon breaks associated with the RFD discharge lines and used to vent flammable gas accumulations vent? Have the potential hazards associated with this venting been fully assessed?	There are no siphon vents in the RFD discharge lines.

LOI#	Line of Inquiry	Conclusion
		Research and Technology
29	What mockup testing results exist for the compressed air purge system for UFP-02 supply lines that demonstrate effective venting of flammable gas?	BNI has completed two testing programs that support design and implementation of the HPAV engineered solutions. Post DBE UFP-2A/B Pump Supply Line Clearing Tests were conducted on a full-scale mockup of this line at SRNL. These tests confirmed the ability of an air purge to remove at least 70% of high shear stress stimulant from the UFP pump suction line and provided requirements on the flow rate and duration of the purge to meet this condition. The PJM Non-Newtonian 'Slug' Internal Mixing Tests confirmed that half stroke operation of the PJMs does not fully mix the retained waste with new waste; a condition that could lead to unacceptable concentration of hydrogen in the PJM. These tests also confirmed that "full stroke" (85% of the length of the PJM) did fully mix new with old waste in the PJM. This testing program is establishing the functional requirements for the Scout Mode of PJM operation. Additional testing is planned to show that adequate mixing occurs with less than 10 full stroke cycles. No additional testing needs have been identified by the Team or BNI at the date of this report to support design and implementation of the HPAV solutions.

Appendix C.
Design Product Oversight Plan
Review of BNI Proposed Controls for
Hydrogen in Piping and Ancillary Vessels (HPAV)
June 2006

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

DESIGN PRODUCT OVERSIGHT PLAN

REVIEW OF BNI PROPOSED CONTROLS FOR HYDROGEN IN PIPES AND ANCILLARY VESSELS (HPAV)

February 21 - March 2, 2006

Design Oversight:	D-06-DESIGN-023
Team Lead:	Bob Griffith
Deputy Team Lead:	Jim Davis
Reviewer(s):	Lew Miller Ko Chen Langdon Holton Larry Demick Vic Descamp Joe Panchison

Submitted by:

Bob Griffith, Team Lead — 1/24/06 Date

Jim Davis, Deputy Team Lead — 1/24/06 Date

Concurrence:

Bill Hamel, Director
WTP Engineering Division — 1/24/2006 Date

John Eschenberg, Project Manager
Waste Treatment and Immobilization Plant — 1/25/06 Date

Design Product Oversight Plan

Review of BNI Proposed Controls for Hydrogen in Pipes and Ancillary Vessels (HPAV)

Table of Contents

1.0 Background and Objectives

1.1 Background

The processing of tank wastes in the Waste Treatment and Immobilization Plant (WTP) facilities will be accompanied by the generation and release of flammable gases. In order to mitigate the potential for accumulations of flammable gas quantities that could lead to deflagrations or detonations, Bechtel National, Inc. (BNI) instituted a number of design constraints (e.g. waste mixing requirements and ventilation requirements) based on estimates of the "time to the lower flammability limit (LFL)." During the earlier stages of project design, the primary emphasis on the control and mitigation of flammable gases was in the head spaces of large process vessels and in the waste matrix within these vessels. Based on the hazards discussed in Nuclear Regulatory Commission Information Notice 2002-15, "Hydrogen Combustion Events in Foreign BWR Piping," a more recent project focus has been on the accumulation and potential hazards associated with flammable gas generation in piping and ancillary vessels. The BNI program established to deal with this design issue is referred to as Hydrogen in Piping and Ancillary Vessels (HPAV).

Using their approved Integrated Safety Management (ISM) process, BNI identified ten generic solutions for the hazards associated with HPAV. These generic solutions incorporate the control strategies identified through the ISM process to adequately prevent or mitigate the flammable gas hazards. The objectives of the design oversight addressed by this plan are identified below.

BNI has advanced these HPAV generic solutions to the point that a meaningful review by U.S. Department of Energy, Office of River Protection (ORP) of their acceptability, as assessed against these objectives, is possible. As such, ORP will perform a design oversight of the proposed HPAV generic solutions in accordance with this Review Plan and the guidance provided in ORP PD 220.1-12, *Conduct of Design Oversight.*

1.2 Objectives

The following are the objectives of this oversight:

1. Determine the technical acceptability, viability and effectiveness of the proposed HPAV generic solutions;

2. Identify any impacts to the WTP flowsheet, throughput, risk register, safety/ authorization basis, or total operating efficiency;

3. Determine if proposed operational requirements/expectations are consistent with equipment access, staffing, coincidental operating requirements, etc; and

4. Determine if proposed HPAV generic solutions are adequately supported by research and technology (R&T) program results.

A set of Lines of Inquiry (LOI) for the performance of this design oversight are identified in Attachment 1. These LOIs may be revised based on presentations made to the Design Oversight Team by BNI at the beginning of the assessment or based on changes in the direction of the assessment found necessary during its performance.

2.0 Process

This oversight shall be conducted shall be conducted within the guidelines of ORP PD 220.12, February 12, 2003, "Conduct of Design Oversight".

2.1 Scope

This oversight shall include review of: 1) BNI technical reports and/or white papers related to the HPAV generic solutions; 2) research and technology (R&T) reports/results/plans related to the HPAV generic solutions; 3) available BNI documentation on operational implications associated with implementation of the HPAV generic solutions; and 4) engineering documentation (including red-lined documents, if that is all that is available) supporting HPAV generic solutions.

2.2 Preparation

1. Identify the BNI Point of Contact for this Design Oversight.

2. Review background information as provided by BNI and identified through review of available design information.

3. Participate in HPAV briefing sessions presented during the beginning of the oversight assessment.

4. Review pertinent design, commissioning & testing, and safety/Authorization Basis documentation to assess the technical acceptability, feasibility and effectiveness of the proposed HPAV generic solutions and interface with cognizant BNI personnel, as appropriate.

5. Review current BNI open HPAV issues and the plans for and status of their resolution.

In this regard, Table 1 identifies the types of information requested to be supplied by BNI to initiate this design oversight.

2.3 Review and identify, resolve, or document issues

Questions generated by review team members during the review of the HPAV generic solutions will be compiled by the ORP Review Team Lead and submitted to BNI for response. The ORP Review Team Lead will complete and maintain a summary table of the ORP questions and BNI responses similar to the example shown in Attachment 2, Appendix A. The output from this phase of the oversight will be a completed summary table, including a list of remaining open issues that need further evaluation by BNI for resolution.

2.4 Reporting

De-brief ORP and BNI management periodically, as necessary, and prepare a draft report that summarizes the activities, the results, conclusions and recommendations of the review. The draft report will be issued for review and comment of ORP management and cognizant BNI personnel. The final report will resolve comments received on the draft report.

3.0 Schedule of Activities

Table 2 summarizes the schedule for completion of this oversight.

4.0 Documentation

The final report of this task shall contain the sections and content as summarized in Attachment 2.

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 Consolidated Action Reporting System (CARS). These shall also be tracked to resolution by BNI through the Correspondence Control Number (CCN) that will be assigned to the transmittal of the report from ORP to BNI. See Table X, Attachment 2.

5.0 Closure

The Team Leader with concurrence of the Director shall confirm that the open items from this oversight are adequately resolved.

Table 1
Initial Information Requirements

1.	Technical reports/white papers related to the HPAV generic solutions.
2.	R&T reports/results/plans related to HPAV generic solutions.
3.	Documentation available on operational implications associated with implementation of the HPAV generic solutions, including impacts to the WTP flowsheet, facility throughput, risk register, total operating efficiency, facility staffing, post-Design Basis Event (DBE) operator actions, etc.
4.	Engineering documentation (or red-lines thereof, if that is all that is currently available) supporting HPAV generic solutions (e.g., revised/new system descriptions, Piping and Instrumentation Diagrams, Process Flow Diagrams, Ventilation and Instrumentation Diagrams, Ventilation Flow Diagrams, mechanical handling diagrams, specifications, calculations).
5.	Roles and responsibilities for HPAV generic solution determination, design, analysis, and implementation throughout the WTP.

Table 2
Schedule

Activity Description	Responsibility	Complete By
Develop Oversight Plan	Griffith	1/26/06
Identify Review Team Lead and members	Hamel	Complete
Review initial information submitted by BNI	Review Team	2/21/06
Perform design oversight assessment	Review Team	2/21 – 3/1/06
Provide questions to Review Team Lead	Review Team	As generated
Provide oversight report input	Review Team	Daily throughout the oversight period, but no later than 3/1/06
Prepare Design Oversight Report (Draft)	Griffith/Davis	3/2/06
Finalize Design Oversight Report	Griffith/Davis	3/16/06
ORP Management and BNI review of draft report	ORP Management and BNI	3/23/06
Resolve comments and issue final report including close out with BNI	Griffith/Davis	3/31/06

Attachment 1

Lines of Inquiry (LOI) for the HPAV Generic Solutions Design Oversight

Scope of HPAV Generic Solutions

1. Do the ten generic HPAV solutions and their derivatives encompass all potential build-ups of flammable gas in WTP pipes and auxiliary vessels? If not, are the ten generic solutions intended to provide adequate control strategies for all potential build-ups of flammable gas in WTP pipes and auxiliary vessels?

Design Acceptability/Viability/Effectiveness

2. How is Pulse Jet Mixer (PJM)/reverse flow diverter (RFD) venting performed?

   a. Is the intent to pulse the flammable gas out of the PJM/RFD using the normal drive cycle from the PJM rack? If so, how is complete flammable gas venting assured and how is a vessel overblow event avoided?
   b. If not, is the intent to vent the flammable gas into the pulse jet vent (PJV) header? If so, is there any potential to build-up flammable gas in the PJV system?
   c. If new vent piping is planned, how is the operability of the PJMs/RFDs not compromised?

   Please be clear in your response as to which actions are automatic, which are remote operator, and which are local manual operator actions.

3. For non-Newtonian vessels/fluids, how is the venting performed to ensure that flammable gas captured in the fluid/waste matrix within the PJM is released as well?

4. What design or operating characteristics exist relative to the jet pump pairs that precludes flammable gas accumulation from being an issue in the piping between the jet pump pair and the air rack isolation valves?

5. How is flammable gas venting accomplished for PJMs/piping between the PJMs and the jet pump pair if the PJM racks are failed due to a DBE?

6.a. How will the design ensure that reboiler and evaporator drain lines adequately drain the waste material to a downstream location?

b. Why isn't the flammable gas accumulation concern extended to the drain system with this approach?

7. How is compressed air purging effective in removing non-Newtonian waste from pump suction piping?

8. Are there potential flammable gas accumulation high points in the piping for Cesium Ion Exchange Process System and Ultrafiltration Process System (UFP) recirculation and, if so, how does BNI plan on periodically venting this flammable gas?

9. What provisions are provided to clear potential plugs in pulse tubes, particularly in non-Newtonian vessels?

10.a. What is the drain installation and flowpath for Waste Feed Evaporation Process System and Cesium Nitric Acid Recovery Process System evaporators and piping header dead legs?

b. Do design documents correctly implement the design requirements for the important to safety flush water system?

11. There are varieties of unverified assumptions in the hydrogen generation rate calculation. Some of the more significant of these were described in the January 12, 2006, Design Oversight Report (05-WED-054). What is the sensitivity of the proposed design to changes in the assumptions questioned in this report; e.g. different presence of organics, sucrose, etc.

12. BNI has proposed to exclude portions of Structures, systems, and components (SSC) from concern based on slow accumulation of flammable gas, strength of SSC material to withstand explosions, and calculations of the strength of the explosion. These proposals are under review by ORP. What is the sensitivity of the proposed design to changes in these criteria; e.g. different acceptable strain levels, different acceptable time criteria, or different calculated strength of explosions.

13. What is the intended design change/HPAV generic solution for capped spare dipped lines having the potential to trap flammable gas? Is this design change effective in preventing the accumulation of flammable gas in these lines?

14. What is the technical basis for excluding components (e.g., thermowells) from requiring HPAV generic controls?

Operational Implications

15. How do the cross-ties between the 50/50 split racks impact the operability of the PJMs? Is the purpose of the cross-tie valves to preclude any such impact?

16. What impacts to constructability, operability, reliability, accessibility, maintainability, and inspectability (CORAMI) occur due to implementation of the HPAV changes?

17. What is the impact to total operating efficiency from implementation of the HPAV changes? To what degree, if any, do HPAV changes impact facility throughput?

18. Explain how BNI has or will determine the time and the time sequence of operator actions required for the selected preventive and mitigative control strategies. How much operator time per shift is estimated to be required to perform these manipulations?

19. Which portions of the SSCs potentially affected by HPAV will be inspected, during operations, for damage due to flammable gas detonation or deflagration? How frequently will these inspections occur?

20. Which portions of the SSCs potentially affect by HPAV will not be inspected, during operations, for damage due to flammable gas detonation or deflagration? What is the basis for the determination that these portions will not be inspected?

21. How is the intending operating approach for the proposed engineering controls for each of the HPAV flammable gas generic solutions (e.g., how often will the air purge or wash be performed, what will direct the operators to perform these operations, how will successful completion be determined)?

Safety/Authorization Basis

22. What additional controls were identified to ensure waste in Radioactive Liquid Waste Disposal System Vessel 008 remains below 2 wt% solids over and above existing controls to limit solids loading?

23.a. Explain which preventive and mitigative control strategies are automatic, and require no operator action to occur. Describe those strategies, including parameters to be sensed, and actuation logic.

b. Detail which, if any, of these automatic actions meet the single failure criterion. (Do not include non-redundant safety class systems using the relaxed single failure criterion currently under review by ORP.)

24. Explain which preventive and mitigative control strategies require some operator actions. Describe those actions, and where they must be performed.

25. Explain why the air system has sufficient capacity, and specifically what assumptions regarding operator performance are made to ensure the available capacity will not be not exceeded. Please include a discussion of how different mixing and purging requirements will be coordinated to ensure the air system is not overloaded. Discuss how periodic and unscheduled repair maintenance will be accommodated.

26. Describe the bounding case flammable gas hazard: Assuming no operator action, an initiating event such as a loss of offsite power, or a design basis earthquake, and a single failure of an active system, what will occur in the facility, over time. Do not stop this discussion with the first explosion of flammable gas, but explain when subsequent explosions would be expected to occur.

27. Why is acceptable to allow an accumulation of flammable gas (8 vol %) greater than the lower flammability limit when evaluating the acceptability of an HPAV generic solution?

28. Where do the siphon breaks associated with the RFD discharge lines and used to vent flammable gas accumulations vent? Have the potential hazards associated with this venting been fully assessed?

Research and Technology

29. What mockup testing results exist for the compressed air purge system for UFP-02 supply lines that demonstrate effective venting of flammable gas?

Attachment 2

Design Oversight Report Outline

The design oversight report should have the following sections, as appropriate:

Cover Page – The cover page includes dates of the design oversight, the report number, the names of the participating oversight reviewer(s) and the name of the ORP design oversight leader who reviewed and approved the report. See Attachment.

Executive Summary – The executive summary of this design oversight should describe the design products reviewed, provide a conclusion on the adequacy of the design product reviewed, and identify significant open issues and the mechanism for tracking resolution of these issues by BNI.

Report Outline

1.0 INTRODUCTION

Summarizes the activity, schedule, purpose, scope and methods of review

2.0 BACKGROUND

Similar to the Background Section of the Design Oversight Plan

3.0 OBJECTIVES, SCOPE AND APPROACH

3.1 Objectives

Lists the objectives from the Design Oversight Plan

3.2 Scope

Summarizes the areas, systems, components, etc, reviewed in the oversight. This is similar to the Scope section of the Design Oversight Plan

3.3 Approach

In the same format as the Design Oversight Plan, summarizes the actual work performed as part of this oversight, e.g., documents reviewed (refers to references and Appendix A), actual meetings held with BNI, BNI meetings attended, preparation of preliminary draft for BNI review and comment, etc.

4.0 RESULTS

This section contains the significant results of the review including detailed description of the bases and recommendations for resolution of Open Issues identified in this review. The Open Issues should be sequentially numbered in this discussion in the order listed in Table X, see below.

This section should be subdivided such that there is a subsection for each objective:

4.1 Objective 1

4.2 Objective 2

5.0 RECOMMENDATIONS

Summary of recommendations for action by BNI and ORP to ensure that open issues are resolved and plans for future oversight reviews.

6.0 REFERENCES

Principal references used in the oversight. Note that the majority of references will be contained in the reviewer summaries contained in Appendix A.

Table X
Summary of Open Issues from the Design Oversight of the BNI Proposed Controls for Hydrogen in Pipes and Ancillary Vessels (HPAV)

Item No[1]	CARS No	Open Issue Summary	Recommendation for Resolution
1.		*Summary of the Issue. This discussion should include the Section and item number reference where the detailed discussion of this issue is located within the main body of the report.*	*Summary of the recommended action to resolve the issue. This discussion should also include the Section and item number reference where the detailed discussion of the recommendation is located within the main body of the report.*

This table is the summary of Open Issues identified in the review and recommendations for BNI resolution of the issues. The listing of each open issue should include a short summary of the issue and the recommended action referenced back to the section of the report that contains the detailed discussion of the issue, e.g., Section 4.1.1, item a. Each item will be assigned an item number and CARS tracking number. It is expected that BNI will also track resolution of these issues via the CCN tracking number assigned to the transmittal of this report from ORP to BNI.

[1] Item No – Each item shall be identified with a unique number and entered into the CARS database for tracking to resolution.

APPENDIX A

(Note: This appendix contains the detailed results of the review. In addition to the responses to the questions and lines of inquiry explored during the oversight this appendix may also contain relevant minutes of meetings between BNI and ORP conducted as part of this review. This is typically a substantial document and is transmitted and handled as a separate document. The following is the format of this appendix.)

RESPONSES TO ORP QUESTIONS AND LINES OF INQUIRY
DESIGN OVERSIGHT
{System or area of review}

{Date}

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

A. …
B. …

{Note: Categories of questions may include or pertain to, for example; Design Status Design Status, Design Requirements, System Descriptions, Calculations, System Descriptions, Modeling, Research and Technology Program, Technical Performance, Additional Questions after the initial discussions with BNI, BNI Resolution of Action Items developed in Multi-Discipline Design Reviews or other meetings. Categories may also include minutes of meetings.}

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

Question - The question or line of inquiry raised by ORP.
Comment - Additional information supplied by ORP to clarify the question.
Response - The BNI response to the question.
Cognizant Discipline - The discipline within BNI that has the primary information on the response.
Group - Questions are categorized into three groups:

A. Questions that have complete responses.

B. Questions related to design information not yet available because of current status of the design. Dates for completion will be provided by {Date to be provided by BNI}.

C. Questions related to alternate system designs, off-design conditions, or actions outside the current scope of work. Partial responses have been provided. No additional work to resolve these questions is planned. Significant effort is expected to resolve these questions and may have significant project cost/schedule impacts.

A. {First category of question}

Question	Comment	Response	Cognizant Discipline	Group

B. {Second category of question}

Question	Comment	Response	Cognizant Discipline	Group

Attachment – Report Cover Page

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

{Title of Oversight}
ORP Design Oversight Report

{Date}

Design Oversight: ______________________

Team Lead: ______________________
{Name}

Reviewers: ______________________
{Name}

____
{Name}

____
{Name}

____
{Name}

Concurrence: ______________________
William F. Hamel, Director
WTP Engineering Division

Approved: ______________________
John Eschenberg, Project Manager
Waste Treatment and Immobilization Plant

Task# ORP-WTP-2006-0143

E-STARS™ Report
Task Detail Report
08/28/2006 0210

TASK INFORMATION			
Task#	ORP-WTP-2006-0143		
Subject	(Concur 06-WTP-109) TRANSMITTAL OF U. S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT: "HYDROGEN IN PIPING AND ANCILLARY VESSELS (HPAV) GENERIC SOLUTIONS" (D-06-DESIGN-023)		
Parent Task#		**Status**	CLOSED
Reference		**Due**	
Originator	Lamoureux, Sandra	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	08/03/2006 1431	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you. bcc: MGR RDG File WTP OFF File WED OFF File L. F. Miller, AB J. J. Short, OPA R. W. Griffith, WED W. F. Hamel, WED L. F. Miller, Acting WTP J. R. Eschenberg, WTP		

ROUTING LISTS

1	Route List	Inactive
	• Griffith, Robert W - Review - Concur - 08/04/2006 0839 *Instructions:*	
	• Hamel, William F - Review - Cancelled - 08/28/2006 1410 *Instructions:*	
	• Miller, Lewis F - Review - Cancelled - 08/28/2006 1410 *Instructions:*	
	• Short, Jeff J - Review - Cancelled - 08/28/2006 1410 *Instructions:*	
	• Eschenberg, John R - Review - Concur - 08/28/2006 0937 *Instructions:*	
	• Schepens, Roy J - Review - Cancelled - 08/28/2006 1410 *Instructions:*	
	• Eschenberg, John R - Approve - Approved - 08/28/2006 0937	

RECEIVED
AUG 2 8 2006
DOE-ORP/ORPCC

Task# ORP-WTP-2006-0143

Instructions:

ATTACHMENTS

No Attachments

COLLABORATION

COMMENTS

No Comments

TASK DUE DATE HISTORY

No Due Date History

SUB TASK HISTORY

No Subtasks

-- end of report --

Task# ORP-WTP-2006-0143

E-STARS™ Report
Task Detail Report
08/03/2006 0235

TASK INFORMATION

Task#	ORP-WTP-2006-0143		
Subject	(Concur 06-WTP-109) TRANSMITTAL OF U. S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) DESIGN OVERSIGHT REPORT: "HYDROGEN IN PIPING AND ANCILLARY VESSELS (HPAV) GENERIC SOLUTIONS" (D-06-DESIGN-023)		
Parent Task#		**Status**	Open
Reference		**Due**	
Originator	Lamoureux, Sandra	**Priority**	High
Originator Phone	(509) 376-9025	**Category**	None
Origination Date	08/03/2006 1431	**Generic1**	
Remote Task#		**Generic2**	
Deliverable	None	**Generic3**	
Class	None	**View Permissions**	Normal
Instructions	Hard copy of the correspondence is being routed for concurrence. Once you have reviewed the correspondence, please approve or disapprove via E-STARS and route to the next person on the list. Thank you. bcc: MGR RDG File WTP OFF File WED OFF File L. F. Miller, AB J. J. Short, OPA ~~R. W. Gilbert~~, WED, R. W. Griffith W. F. Hamel, WED L. F. Miller, Acting WTP J. R. Eschenberg, WTP		

ROUTING LISTS

1	Route List	Active
	• Griffith, Robert W - Review - ~~Awaiting Response~~ RWG 8/4/06 *Instructions:*	
	• Hamel, William F - Review - Awaiting Response WFH 8/7/06 *Instructions:*	
	• Miller, Lewis F - Review - Awaiting Response LFM 8/25/06 *Instructions:*	
	• Short, Jeff J - Review - Awaiting Response JJS 8/25/06 *Instructions:*	
Rec'd 8/28	• Eschenberg, John R - Review - Awaiting Response 8/27 04 *Instructions:*	
	• Schepens, Roy J - Review - Awaiting Response *Instructions:*	
	• Eschenberg, John R - Approve - Awaiting Response	