OFFICE OF RIVER PROTECTION
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18-NSD-0026

The Honorable Bruce Hamilton
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Dear Chairman Hamilton:

RESOLUTION OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD ISSUES: CONCERNS REGARDING THE SAFETY DESIGN STRATEGY FOR THE WASTE TREATMENT AND IMMOBILIZATION PLANT HIGH-LEVEL WASTE FACILITY

References: See page 3

The Defense Nuclear Facilities Safety Board (DNFSB) sent three letters (References 1, 2, and 3) to the U.S. Department of Energy (DOE), Assistant Secretary for Environmental Management regarding the safety design strategy for the High-Level Waste (HLW) Facility at the Waste Treatment and Immobilization Plant. In the letters, the DNFSB expressed concerns relating to: 1) unanalyzed melter accident scenarios; 2) hydrogen control strategy; and 3) seismic classification of components of the confinement ventilation system.

In the DNFSB's *27th Annual Report to Congress* (Reference 4), the issues identified were summarized as follows:

> *Unanalyzed Melter Accidents* – In a December 5, 2014, letter to DOE, the Board communicated its concern that implementation of the nuclear safety control strategy for the melter and associated support systems in the Safety Design Strategy (SDS), could produce a design that is insufficient to protect the public and the workers. The Board identified several melter accident scenarios that were not analyzed in the SDS. As a result, the SDS does not identify nuclear safety controls for these accidents. DOE is evaluating these melter accidents to identify appropriate nuclear safety controls.
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> *HLW Hydrogen Control Strategy* – In a January 21, 2015, letter to DOE, the Board communicated its concern that the SDS for the HLW Facility does not define a nuclear safety control strategy for hydrogen explosion hazards following the loss of mixing in the process vessels. This hazard, if not properly addressed, may result in releases of radioactive materials. The Board also expressed concern that the WTP project team plans to rely on evaluations for resolving similar issues in the PT Facility to inform the development of a hydrogen control strategy for the HLW Facility. DOE is evaluating the accident to determine a nuclear safety control strategy.

Seismic Categorization of Safety Controls – In a February 2, 2015, letter to DOE, the Board communicated its concern that the SDS for the HLW Facility did not ensure that the confinement ventilation system, known as "C5V," would be able to perform its credited safety class functions effectively. The SDS proposed downgrading the seismic classification of several key components. Following a seismic design basis accident, these downgrades could result in penetrations through the C5V confinement boundary that compromise safety functions protecting workers and the public. DOE is evaluating the seismic event to validate the seismic classification of safety controls.

As committed to in DOE's initial responses to the DNFSB (References 5, 6, and 7) these concerns were addressed as part of the process hazards analysis and control selection performed in support of revising the HLW Facility Preliminary Documented Safety Analysis (Reference 8). The purpose of this letter is to notify the DNFSB that with the approval of the HLW Facility Preliminary Documented Safety Analysis revision on September 27, 2017 (Reference 9), the DOE Office of River Protection considers the DNFSB issues resolved. The Attachment provides further details on how the issues were addressed in the HLW Facility Preliminary Documented Safety Analysis revision.

If you have any questions, please contact me, or your staff may contact Thomas W. Fletcher, Assistant Manager, Federal Project Director, Waste Treatment and Immobilization Plant, (509) 376-4941.

Brian T. Vance
Manager

NSD: KRS

Attachment

cc w/attach:
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BNI Correspondence

References:

1. DNFSB letter from P.S. Winokur to M. Whitney, HQ, "Melter Accidents Unanalyzed in the Safety Design Strategy for the High-Level Waste Facility," dated December 5, 2014.

2. DNFSB letter from J.H. Roberson to M. Whitney, HQ, "Hydrogen Control Strategy in the Safety Design Strategy for the High-Level Waste Facility," dated January 21, 2015.

3. DNFSB letter from J.H. Roberson to M. Whitney, HQ, "Seismic Control Strategy Deficiencies in the Safety Design Strategy for the High-Level Waste Facility," dated February 2, 2015.

4. *27th Annual Report to Congress*, Defense Nuclear Facilities Safety Board, Washington, D.C., dated April 27, 2017.

5. HQ letter from M. Whitney to J.H. Roberson, DNFSB, "Regarding Unanalyzed Melter Accidents in the Safety Design Strategy for the High-Level Waste Facility," dated March 9, 2015.

6. HQ letter from M. Whitney to J.H. Roberson, DNFSB, "Regarding the Hydrogen Control Strategy in the Safety Design Strategy for the High-Level Waste Facility," dated June 5, 2015.

7. HQ letter from M. Whitney to J.H. Roberson, DNFSB, "Regarding the Confinement Ventilation Seismic Control Strategy in the Safety Design Strategy for the High-Level Waste Facility, dated July 24, 2015.

8. BNI letter from K.D. Irwin to W.F. Hamel, ORP, "Supersedes CCN 296651 and CCN 298892 – Regulatory Deliverable 9.1 – Preliminary Documented Safety Analysis Change Package for the Preliminary Documented Safety Analysis to Support Construction Authorizaton [sic]; HLW Facility Specific Information," CCN: 298893, dated September 14, 2017.

9. ORP letter from K.W. Smith to M.G. McCullough, BNI, "Approval of Preliminary Documented Safety Analysis Change Package for 24590-WTP-PSAR-ESH-01-002-04, *Preliminary Documented Safety Analysis to Support Construction Authorization; HLW Facility Specific Information,* Rev. 7," 17-NSD-0033, dated September 27, 2017.

Attachment
18-NSD-0026
(6 Pages Excluding Cover Sheet)

Response to Defense Nuclear Facilities Safety Board Issues Regarding Unanalyzed Melter Accidents, Hydrogen Explosion Hazards, and C5V Functionality Following a Seismic Event in the High-Level Waste Facility

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:
Unanalyzed HLW Melter Accidents [Reference: DNFSB Letter to EM, dated December 5, 2014]	The DNFSB identified four unanalyzed melter accidents not addressed in the HLW SDS (24590-HLW-PL-ENS-13-0001, Rev. 0). The four unanalyzed melter accidents are listed below. 1. Melter Steam Explosion – "The SDS does not identify a melter steam explosion initiated by a molten salt and water interaction. Formation of a molten salt (e.g., sulfate) layer on top of the melt pool can occur when the melter feed chemistry is out of specification. The molten salt layer has a lower viscosity that allows for premixing to occur if water enters the melter and contacts the molten salt layer. Water is supplied to the melter during normal operations through routine flushes of the slurry feed pumps. Hazards from a large steam explosion include rapid steam generation, aerosol production, damage to the melter and the melter offgas system, and loss of molten glass and offgas confinement." 2. Simultaneous Spill of Molten Glass and Water – "The melter caves contain numerous water sources that are not designed to withstand a design basis accident. Examples include the submerged bed scrubber, melter cooling panels, cooling supply lines to melter feed nozzles, and high efficiency mist eliminators (HEME). The SDS does not analyze the scenario where a design basis seismic accident breaches the melter and molten glass spills simultaneously with water from the various water sources. This accident could result in cooling water flashing upon contact with molten glass and producing large amounts of steam and aerosols." 3. Simultaneous Spill of Molten Glass and Nitric Acid – "Each melter cave contains two safety significant HEMES located in close proximity to the melter. The capability is being provided to fill the HEME with nitric acid and allow the HEME to soak, thus facilitating solids removal. In the event of a design basis seismic accident during a HEME acid soak, the contents of the HEME could spill onto the melter cave floor, where they could mix with molten glass and water	Report FAI/14-0627, *Steam Explosions with Molten Glass Compounds and Their Relationship to the Hanford Waste Treatment Plant (WTP) Glass Melter Designs* (CCN: 271242) evaluates potential water and molten glass interactions. The report was used in the hazards analysis to evaluate the postulated scenarios. 1. Melter Steam Explosion – The HLW PDSA, Appendix C, "Melter Process," Table C-1, "Melter Process What-If Table," Postulated Accident Scenario 2.2.1, evaluates the potential for an explosion to occur due to salt layer formation on the surface of the molten glass pool interacting with a water addition. The results of the evaluation reflect the potential scenario would result in only limited steam formation (not explosion) due to the low rate of water addition coupled with the fact a sulfur layer already exposed to oxygen present in the melter would have limited potential for further oxidation due to a water addition. The "Notes" section of Table C-1 for scenario 2.2.1 provides additional explanation and technical details. 2. Simultaneous Spill of Molten Glass and Water – The HLW PDSA, Appendix C, Table C-1, Postulated Accident Scenarios 2.2.5 and 2.2.6 evaluate the potential for an explosion due to water and molten glass interactions. The results of the evaluation reflect the potential scenarios would result in only limited steam formation (not an explosion) based on report FA/14-0627. The "Notes" section of Table C-1 for scenarios 2.2.5 and 2.2.6 provides additional explanation and technical details. 3. Simultaneous Spill of Molten Glass and Nitric Acid – The HLW PDSA, Appendix C, Table C-1, Postulated Accident Scenarios 7.2.3 and 7.2.4 evaluate the potential for molten glass interactions with water or nitric acid during a seismic event. The design of the melter shell (seismic performance criteria) serves to limit the potential for a molten glass spill and such interactions. The "Notes" sections of Table C-1 for scenarios 7.2.3 and 7.2.4 provide additional explanation and technical details. 4. Loss of Melter Cooling – The HLW PDSA, Appendix C, Table C-1, Postulated Accident Scenarios 3.2.12 and 3.2.12a evaluate the potential effects of melter cooling panel failure (3.2.12) or cooling panel failure due to water/steam intrusion

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:
	released from the melter. Heated nitric acid produces corrosive vapors that could be carried into the ventilation system." 4. Loss of Melter Cooling – "The SDS does not identify nuclear safety controls for a melter cooling panel rupture of loss of cooling to the melter. The manufacturer's system description for the HLW states that the refractory package has been designed to provide adequate containment of glass in the event of a temporary loss of cooling water flow. However, during a sustained loss of cooling water flow, the cooling panels will eventually boil dry. This condition will lead to rapid heating of the refractory and melter cooling panels, which may then lead to increased corrosion of the refractories, glass leakage and cooling panel warping."	(3.2.12a). Document 24590-101-TSA-W000-0010-407-566, *RPP-WTP HLW Melter System Description*, indicates there are inherent features incorporated into the melter design to prevent such failures. The HLW PDSA reflects the potential for such events are reduced by reliance upon the melter shell to maintain confinement of the molten glass (SS-DF). The "Notes" sections of Table C-1 for scenarios 3.2.12 and 3.2.12a provide additional explanation and technical details.
HLW Hydrogen Control Strategy [Reference, DNFSB letter to EM, dated August 3, 2011, and DNFSB letter to EM, dated January 21, 2015a]	The DNFSB "believes that the analysis performed to date are not reasonably conservative and do not support decisions to downgrade mixing controls" and "The WTP contractor plans to rely on evaluations for resolving similar hazards in the Pretreatment (PT) Facility to support and inform the development of a safety design strategy for the HLW Facility. Due to significant differences in the design of the mixing systems and waste properties at these two facilities, evaluations for the PT Facility may not be applicable to the HLW Facility."	BNI calculation 24590-WTP-M4C-M12T-00001, *Vessel Temperature Calculations During a Post-Design Basis Event Using the FATE Model*, was developed to determine: (a) the temperature of PT Facility (and HLW) process vessels as a function of time during off-normal conditions (loss of in-bleed cooling effects; loss of process vessel ventilation; and loss of vessel cooling jackets); (b) the sensitivity of the waste temperature to room and surrounding environmental conditions; and (c) the sensitivity of the waste temperature to liquid and sludge layer properties. 24590-WTP-M4C-M12T-00001, Table 8, "Results of Waste Temperature Calculations," reflects that the temperature of the waste in HLW process vessels (HFP-VSL-00001/2/5/6) decreases as a function of time upon loss of cooling. A new FATE sensitivity analysis was performed for the proposed SHSV design (24590-PTF-ES-NS-15-003, *Proposed Control of Hydrogen Events in the Pretreatment Facility Pulse Jet Mixed Process Vessels*, Appendix C, "Vessel Temperature Calculations and UHGRs for AY-102 and AP-103 Feed Blend"). The FATE model results for the SHSV reflect that although there can be an initial temperature increase due to radiolytic heating effects, the use of the maximum operating temperature for the entire duration of a loss of cooling event remains conservatively bounding for purposes of estimating the unit hydrogen generation rate. Therefore, the hydrogen generation rates estimated in 24590-WTP-M4C-

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:
		V11T-00011, *Revised Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit for WTP*, remain based on the maximum operating process temperature for the HLW vessels (140°F). The hydrogen generation rates from 24590-WTP-M4C-V11T-00011 were used to update 24590-HLW-Z0C-H01T-00001, *Unmitigated Consequences from HLW Hydrogen Explosions*. The results of calculation 24590-HLW-Z0C-H01T-00001 have been incorporated into the HLW PDSA. Both calculations (24590-WTP-M4C-V11T-00011 and 24590-HLW-Z0C-H01T-00001) are listed as references for Chapter 3. The potential hydrogen explosions in vessels are evaluated in the HLW hazard analysis (see Appendix B, "Melter Feed Process," Table B-1, "Melter Feed Process What-If Table," Postulated Accident Scenario ID No. 1.1.5b, 2.1.2, 2.1.3, 2.1.15, 2.1.19, 3.1.68, 3.1.79, 3.1.81, 3.1.85, 6.1.5, 6.1.8, and 6.1.11; Appendix K, "Facility-Wide What-If Tables," Postulated Accident Scenario ID No. 3.8.8, 7.8.5, and 7.8.29; and Table B-2, "Melter Feed Process PrHA Tables," PrHA ID No. {Accident Group} 2.1.2 and 2.1.3). These postulated events include both episodic and non-episodic hydrogen releases leading to potential hydrogen explosions in vessels. Variations of these events caused by loss of agitation and NPH/external events leading to loss of power are also evaluated (see Appendix B, Melter Feed Process, Table B-2, Melter Feed Process PrHA Tables, PrHA ID No. {Accident Group} 2.1.18) and Appendix K, Facility-Wide, Table K-2, Facility Wide PrHA Tables, PrHA ID No. {Accident Group} 6.8.2a, 7.8.27, 7.8.28). HLW PDSA, Section 3.3.3.2, "Explosions," describes the bounding explosion accident scenarios, including hydrogen explosions in vessels. The HLW PDSA incorporates a control strategy for hydrogen that relies upon prevention using a combination of periodic waste agitation coupled with a forced air purge of the vessel head space with exhaust of any hydrogen through the process vessel vent system to an elevated stack. The preventive controls are augmented by the vented vessel and PVV system passive design features coupled with the C5V passive confinement boundary and active HEPA filtration system to mitigate any potential releases from a hydrogen explosion. Safety functions, functional

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:
		requirements and performance criteria are established in Chapter 4 for the following: • HFP vessels for vent path and non-fragmentation: Sections 4.4.2.3.1, 4.4.2.3.3, and 4.4.2.3.4 • HFP vessel headspace air purge and purge piping: Sections .4.2.5.1, 4.4.2.5.2, 4.4.2.5.4, and 5.5.2.1.2 • HFP vessel agitation: Sections 4.4.2.6.1, 4.4.2.6.2, 4.4.2.6.4 and 5.5.2.1.4 • HOP active filtration: Sections 4.4.4.3.1, 4.4.4.3.2 and 4.4.4.3.4 C5V confinement and active filtration: Sections 4.4.6.1.1, 4.4.6.1.2, and 4.4.6.1.4 • C5 confinement boundary: Sections 4.4.6.2.1, 4.4.6.2.2, and 4.4.6.2.4 • Seismic performance criteria: Section 4.4.1.1.4 as SC-1 and PC-3. A specific administrative control on waste acceptance criteria is also established in Section 4.5.1 and Section 5.5.3.3 to protect the limits of analytical basis (i.e., UHGR, radioactive content). Based on the results of the analyses and the hydrogen control strategy, spargers are not required for hydrogen control in the HLW Facility.

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:
Seismic Categorization of Safety Controls [Reference: DNFSB letter to EM, dated February 2, 2015b]	The C5V system may not be able to perform its safety class credited safety function following a seismic design basis event. The main concern is that the melter pressure relief valves and HOP system (including the Submerged Bed Scrubber) were being downgraded to SC-III and may fail following a seismic DBA, challenging the capacity of the C5V system. Consequently, reanalysis and/or redesign including additional controls may be required.	Potential HOP system failures leading to a radiological or hazardous chemical release are extensively evaluated in the HLW PDSA (see Appendix E, "Offgas Treatment Process," Table E-1, "Offgas Treatment Process What-If Table" and Table E-2, "Offgas Treatment Process PrHA Tables"). The HOP system is SC-III and the C5V passive and active ventilation system is SC-I to mitigate the potential for offgas releases resulting from a design basis earthquake. The HOP system with the booster fans and extraction fans is designed to minimize disruptions of melter feed. Test results involving the new HLW HEPA filter design indicate that the filters have significantly enhanced performance capability with respect to particulate loading and differential pressures the filters are capable of withstanding (24590-WTP-RPT-HV-17-002, *WTP Remote Change Radial Flow HEPA Filter Qualification Report*). Planned design and safety improvements have been included in the HLW PDSA in Section 3.3.2.3.1 to further evaluate the potential structural response of the PVV/HOP system to a potential hydrogen explosion and to further evaluate the HOP system for off-normal conditions.

24590-101-TSA-W000-0010-407-566, *RPP-WTP HLW Melter System Description*, Rev. 0, Bechtel National, Inc., Richland, Washington, October 22.

24590-HLW-PL-ENS-13-0001, 2014, *Safety Design Strategy for the High-Level Waste Facility*, Rev. 0, Bechtel National, Inc., Richland, Washington, October 22.

24590-HLW-Z0C-H01T-00001, 2017, *Unmitigated Consequences from HLW Hydrogen Explosions*, Rev. H, Bechtel National, Inc., Richland, Washington, February 7.

24590-PTF-ES-NSE-15-003, 2016, *Proposed Control of Hydrogen Events in the Pretreatment Facility Pulse Jet Mixed Process Vessels*, Rev. C, Bechtel National, Inc., Richland, Washington, November 3.

24590-WTP-M4C-M12T-00001, 2012, *Vessel Temperature Calculations During a Post-Design Basis Event Using the FATE Model*, Rev. A, Bechtel National, Inc., Richland, Washington, May 31.

24590-WTP-M4C-V11T-00011, 2010, *Revised Calculation of Hydrogen Generation Rates and Times to Lower Flammability Limit for WTP*, Rev. C, Bechtel National, Inc., Richland, Washington, May 7.

24590-WTP-PSAR-ESH-01-002-04, 2017, *Preliminary Documented Safety Analysis to Support Construction Authorization: HLW Facility Specific Information*, Rev. 7, Bechtel National, Inc., Richland, Washington, October 3.

24590-WTP-RPT-HV-17-002, 2017, *WTP Remote Change Radial Flow HEPA Filter Qualification Report*, Rev. 0, Bechtel, National, Inc., Richland, Washington, August 23.

DNFSB 2011, "Heat Transfer Analyses for Process Vessels in the Pretreatment Facility, Waste Treatment and Immobilization Plant, Hanford Site," (external letter to D. Huizenga, U.S. Department of Energy, Office of Environmental Management), from P.S. Winokur, Defense Nuclear Facilities Safety Board, Washington, D.C., August 3.

DNFSB 2014, "Melter Accidents Unanalyzed in the Safety Design Strategy for the High-Level Waste Facility," (external letter to M. Whitney, U.S. Department of Energy, Office of Environmental Management), from P.S. Winokur, Defense Nuclear Facilities Safety Board, Washington, D.C., December 5.

DNFSB 2015a, "Hydrogen Control Strategy in the Safety Design Strategy for the High-Level Waste Facility," (external letter to M. Whitney, U.S. Department of Energy, Office of Environmental Management), from J.H. Roberson, Defense Nuclear Facilities Safety Board, Washington, D.C., January 21.

DNFSB 2015b, "Seismic Control Strategy Deficiencies in the Safety Design Strategy for the High-Level Waste Facility," (external letter to M. Whitney, U.S. Department of Energy, Office of Environmental Management), from J.H. Roberson, Defense Nuclear Facilities Safety Board, Washington, D.C., February 2.

Crosswalk of Defense Nuclear Facilities Safety Board Safety Design Strategy Concerns with the High-Level Waste Facility Preliminary Documented Safety Analysis Revision

DNFSB Concern:	Description of Concern:	Resolution:

FAI/14-0627, 2014, *Steam Explosions with Molten Glass Compounds and Their Relationship to the Hanford Waste Treatment Plant (WTP) Glass Melter Designs*, Fauske & Associates, LLC, Burr Bridge, Illinois, December.

C5V	=	C5 ventilation system.
DNFSB	=	Defense Nuclear Facilities Safety Board.
HEPA	=	high-efficiency particulate air.
HFP	=	HLW melter feed process.
HLW	=	high-level waste.
HOP	=	HLW melter offgas treatment process.
NPH	=	natural phenomena hazard.
PDSA	=	preliminary documented safety analysis.
PrHA	=	process hazard analysis.
PT	=	pretreatment.
PVV	=	process vessel vent exhaust system.
SDS	=	safety design strategy.
SHSV	=	standard high-solids vessel.
SS-DF	=	safety-significant-design feature.
UHGR	=	unit hydrogen generation rate.