Peter S. Winokur, Chairman
Jessie H. Roberson, Vice Chairman
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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

December 5, 2014

Mr. Mark Whitney
Acting Assistant Secretary for
Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Mr. Whitney:

The nuclear safety control strategy for the melter and associated support systems in the Safety Design Strategy (SDS) for the High-Level Waste (HLW) Facility at the Hanford Waste Treatment and Immobilization Plant could produce a design that is insufficient to ensure adequate protection of the public and the workers. The SDS does not analyze for certain accidents associated with the HLW Facility melters. An incomplete SDS can lead to a safety basis that does not meet the requirements of Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management*. The Defense Nuclear Facilities Safety Board's (Board) staff raised many of these issues in 2011 and 2012 but the project has not resolved them. Now that the Department of Energy (DOE) has approved a conditional authorization for the project to proceed with engineering, procurement, and construction activities, it is prudent to bring these issues to the attention of the DOE Office of Environment Management's leadership. Further details on the issues are provided in the enclosed report.

Pursuant to 42 U.S.C. § 2286b(d), the Board requests a written response within 90 days of the issuance of this letter documenting DOE's intent and plan to address all design basis melter accident scenarios to support development of a compliant safety basis for the HLW Facility and assure the adequate protection of the public and the workers.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Dr. Monica Regalbuto
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

October 17, 2014

MEMORANDUM FOR: S. A. Stokes, Technical Director

COPIES: Board Members

FROM: B. Boser, S. Seprish, R. Kazban

SUBJECT: Summary of Melter Accidents Unanalyzed in the Safety Design Strategy for the High-Level Waste Facility

Members of the Defense Nuclear Facilities Safety Board's (Board) staff conducted a review of the Safety Design Strategy (SDS) for the High-Level Waste (HLW) Facility at the Hanford Waste Treatment and Immobilization Plant (WTP). Members of the Board's staff met with the Department of Energy (DOE) review team on April 22, 2014, to communicate preliminary concerns about the SDS. On July 16, 2014, the Board's staff members held a follow-up discussion with personnel from DOE and Bechtel National, Incorporated (BNI) to discuss outstanding concerns with the SDS. An outbrief regarding the review conclusions was conducted with DOE and BNI personnel on September 9, 2014. One conclusion discussed during the outbrief was that the SDS does not sufficiently analyze accident scenarios involving the melters in the HLW Facility. Therefore, the SDS does not contain an adequate nuclear safety control strategy.

Background. In 2012, DOE restricted engineering, procurement, and construction work for the HLW Facility due to unresolved technical and programmatic issues, as well as misalignments of the design and safety basis. In October 2013, the DOE Office of River Protection (ORP) identified activities that BNI must perform to support a conditional authorization to proceed with engineering, procurement, and construction work. One of the prerequisites was for BNI to develop and submit an SDS for the HLW Facility. On August 1, 2014, the DOE-ORP manager and WTP Federal Project Director approved the SDS with concurrence from the DOE Chief of Nuclear Safety and the Associate Deputy Assistant Secretary for Safety, Security, and Quality Programs for Environmental Management.

The SDS "provides the basis for updating, and ultimately revising, the preliminary documented safety analysis (PDSA) for the [HLW] Facility to ensure the final design is compliant with 10 CFR [Code of Federal Regulations] 830, Part B, *Nuclear Safety Management.* This SDS is a re-alignment to guide future hazard analyses, design activities, and technical issue resolutions, culminating in a revised PDSA to be submitted for approval" [1]. An SDS is a concept from DOE-STD-1189, *Integration of Safety into the Design Process,* and is typically developed early in the project life to guide design and safety basis development. However, this

SDS is a unique, tailored application of the concept to a partially constructed facility with several outstanding technical issues and a previously approved PDSA. Additionally, DOE-STD-1189 is not required by the WTP contract. The HLW SDS contains the preferred nuclear safety controls for the facility. The content and nuclear safety control strategy outlined in the SDS will have direct implications on the safety basis. Therefore, a deficient SDS may lead to incomplete reconstitution of the PDSA and a safety basis that does not meet the requirements of 10 CFR 830.

Unanalyzed Melter Accidents. Members of the Board's staff identified several HLW Facility melter accident scenarios that are unanalyzed in the SDS. These accidents should be analyzed and corresponding nuclear safety control strategies developed in support of the PDSA.

Melter Steam Explosion—Steam explosions can occur when a cold, vaporizable liquid (e.g., water) comes in contact with a hot liquid (e.g., molten glass or molten salt). Steam explosions occur when the rate of vaporization of the cool liquid is rapid enough to generate shock waves. This requires pre-mixing of the liquids and superheating of the cold liquid above the spontaneous nucleation temperature. There are certain melter operating conditions where a steam explosion may be possible. The SDS identifies one potential initiator of a steam explosion, inadvertent injection of water through the air bubblers into the center of the molten glass pool.

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 the 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 pre-mixing 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. The release from a steam explosion would add additional loading to the C5 ventilation (C5V) system high efficiency particulate air (HEPA) filters that is not accounted for in the design of the system. The molten salt and water initiator for a steam explosion will require different nuclear safety controls than those intended for a steam explosion initiated by water injection through the bubblers. The appropriate nuclear safety controls may not be identified given that this accident is not included in the SDS.

The molten salt and water initiated steam explosion hazard is well-known within another WTP facility and other DOE vitrification facilities. The Low Activity Waste Facility PDSA addresses the possibility of a steam explosion for both water-sulfate interactions and water injection through the bubblers [2]. The Low Activity Waste Facility PDSA does not analyze this scenario for other molten salts besides sulfate. Also, a melter steam explosion initiated by a molten salt and water interaction was analyzed for the Defense Waste Processing Facility (DWPF) at the Savannah River Site and was included as part of its safety basis [3]. DWPF has a specific administrative control to ensure salt concentrations do not exceed solubility limits in the glass to prevent a melter steam explosion.

BNI personnel stated during the July follow-up discussion that this is a credible mechanism for a steam explosion and a nuclear safety control strategy will need to be identified. The melter steam explosion accident is a longstanding Board's staff issue. This accident was previously identified and communicated to DOE and BNI in a December 6, 2012, staff review. However, the hazard was not identified in the SDS that DOE approved on August 1, 2014.

Simultaneous Spill of Molten Glass and Water—The melter caves contain numerous water sources that are not designed to withstand a design basis seismic 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 identifies a spill of the entire melter contents due to melter degradation and a catastrophic failure of the melter from a steam explosion initiated by water injection through the bubblers. The SDS also states that molten glass spills and molten glass-water interactions can occur following the design basis seismic accident. However, 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 the molten glass and producing large amounts of steam and aerosols. The volume of steam produced may compromise the safety class C5V system's ability to maintain cascade airflow from areas of lower contamination to areas of higher contamination. The steam generated from this event may also cause the C5V HEPA filters to fail. Failure of the radial HEPA filters under elevated temperature and high humidity conditions is a longstanding issue with the WTP HEPA filter design efforts.

The seismic detection system described in the SDS includes termination of the utility water supply following detection of a design basis seismic accident. However, there will still be volumes of water present even if the isolation valves have been tripped by the seismic detection system.

The simultaneous spill of molten glass and water accident is another longstanding Board's staff issue that was first identified and communicated to DOE and BNI during a May 26, 2011, video-teleconference review. This issue was communicated again during a December 6, 2012, follow-up review. The issue is documented in an open BNI Project Issues Evaluation Report [4], but was not identified in the DOE-approved SDS.

Simultaneous Spill of Molten Glass and Nitric Acid—Each melter cave contains two safety significant HEMEs located in close proximity to the melter. The system description for the HLW Melter Offgas Treatment Process system states: "The capability is being provided to fill the HEME with nitric acid and allow the HEME to soak, thus facilitating solids removal" [5]. In the event of a design basis seismic accident during a HEME nitric acid soak, the contents of the HEME could spill onto the melter cave floor, where they could mix with molten glass and water released from the melter. Heated nitric acid produces corrosive vapors that could be carried into the ventilation system. This issue was initially communicated to DOE and BNI during a December 6, 2012, review. However, the hazard was not identified in the DOE-approved SDS.

Loss of Melter Cooling—The SDS does not identify nuclear safety controls for a melter cooling panel rupture or loss of cooling to the melter. The SDS specifies in section 4.1.3, titled "Additional Data Needed," that additional analysis is needed for this event, but the analysis is not required to be performed based on the SDS implementation procedures. The manufacturer's system description for the HLW melter states that "[t]he 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 refractories, glass leakage, and cooling panel warping" [6].

Conclusions. Members of the Board's staff are concerned that implementation of the nuclear safety control strategy for the melter and melter support systems in the SDS will be insufficient to ensure adequate protection of the workers and the public. An incomplete SDS can lead to future misalignments between the design and safety basis and a safety basis that does not meet the requirements of 10 CFR 830. All credible melter accidents will need to be addressed through hazard and accident analyses in support of the PDSA updates.

References.

[1] Bechtel National, Incorporated, *Safety Design Strategy for the High-Level Waste Facility*, 24590-HLW-PL-ENS-13-0001, Rev 0, June 23, 2014.

[2] Bechtel National, Incorporated, *Preliminary Documented Safety Analysis to Support Construction Authorization; LAW Facility Specific Information,* 24590-WTP-PSAR-ESH-01-002-03, Rev 5g, October 2013.

[3] Savannah River Site, *Final Safety Analysis Report, Savannah River Site, Defense Waste Processing Facility,* WSRC-SA-6, Volume 6, Rev 32, July 2013.

[4] Bechtel National, Incorporated, *Hazardous Condition Not Identified in HLW Hazards Analysis and PDSA,* 24590-WTP-PIER-MGT-11-0453-B Rev. 0, May 24, 2011.

[5] Bechtel National, Incorporated, *System Description for the HLW Melter Offgas Treatment Process and Process Vessel Vent Exhaust (HOP and PVV Systems)*, 24590-HLW-3YD-HOP-00001, Rev 2, August 2010.

[6] Duratek, *HLW Melter System Description,* 24590-101-TSA-W000-0010-407-566, February 10, 2003.