DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

January 7, 2016

The Honorable Frank G. Klotz
Administrator
National Nuclear Security Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Administrator Klotz:

Members of the Defense Nuclear Facilities Safety Board's (Board) staff conducted a review of the safety basis for the Tritium Extraction Facility at the Savannah River Site. This review identified three safety issues: (1) new controls to protect the collocated worker may be needed for some accident scenarios; (2) the tritium control rooms have no remote indication of the tank level for the fire suppression system water supply and support systems for the fire suppression system are not credited as safety-significant; and (3) the Tritium Extraction Facility safety basis credits Safety Management Programs for specific risk reductions in the hazard analysis without identifying Specific Administrative Controls, which is inconsistent with Department of Energy Standard 1186-2004, *Specific Administrative Controls*. These issues, as well as additional observations, were communicated to the Savannah River Field Office during the staff's review.

We understand that many of these issues will be addressed in an annual safety basis update scheduled for fiscal year 2017. Completion of this update in a timely manner is important because the control set credited to protect the collocated worker may change as a result of modifications to the analysis methodology. The enclosed report documents the Board's staff's issues and is provided for your information and use as the safety basis is updated.

Sincerely,

Joyce L. Connery
Chairman

Enclosure

c: Mr. Douglas J. Dearolph
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

September 18, 2015

MEMORANDUM FOR: S. A. Stokes, Technical Director

COPIES: Board Members

FROM: M. Dunlevy, Z. Beauvais, C. Berg

SUBJECT: Tritium Extraction Facility Safety Basis Review

Members of the Defense Nuclear Facilities Safety Board's (Board) staff performed a review of the safety basis for the Tritium Extraction Facility (TEF) [1] at the Savannah River Site (SRS). To support this effort, the Board's staff team performed two onsite reviews of the tritium facilities during May and December 2014, and conducted a series of teleconferences in 2014 and 2015 with representatives from the Savannah River Field Office (SRFO), Savannah River Nuclear Solutions, LLC (SRNS), Pacific Northwest National Laboratory, and the Pacific Northwest Site Office.

During this review effort, the staff team identified the following safety issues:

- New controls to protect the collocated worker may be needed for accident scenarios currently reported to have "moderate" unmitigated and mitigated radiological consequences, as these consequences may be elevated to "high" following the planned implementation of new atmospheric dispersion parameters.

- The tritium control rooms have no remote indication of the tank level for the safety-significant (SS) TEF fire suppression system (FSS) water supply, and FSS support systems are not credited as SS.

- The TEF safety basis credits Safety Management Programs (SMP) for specific risk reductions in the hazard analysis, which is inconsistent with Department of Energy (DOE) Standard 1186-2004, *Specific Administrative Controls* (SAC).

The staff team also noted observations regarding the treatment of asphyxiation hazards and the utilization of safety basis calculations with assumptions that were both non-conservative and not technically justified. The Board's staff team communicated these issues and observations to SRFO and SRNS personnel. In response, SRNS personnel stated that they plan to address the majority of these issues in an upcoming safety basis update. Since the time of the review, the schedule for updating the safety basis to include these changes has slipped from October 2016, as initially planned, to later in fiscal year 2017. Completion of this update in a timely manner is important because the control set credited to protect the collocated worker may change as a result of modifications to the analysis methodology.

Facility Description. In February 2007, TEF began operations to extract and purify tritium from Tritium Producing Burnable Absorber Rods following irradiation in commercial nuclear power reactors. Tritium extracted from the rods and purified in TEF is transferred to H-Area New Manufacturing for processing and reservoir loading, and then transferred to H-Area Old Manufacturing for finishing, packaging, and shipment.

Atmospheric Dispersion Parameter Update. SRS is currently undergoing a site-wide effort to update the atmospheric dispersion parameters used in facility accident analyses [2]. The atmospheric dispersion parameter update resulted from SRNS personnel discovering that they did not appropriately account for site-specific surface roughness when assigning atmospheric stability classes, as described in the Environmental Protection Agency (EPA) document, EPA-454/R-99-005, *Meteorological Monitoring Guidance for Regulatory Modeling Applications* [3]. As a result, the calculated radiological dose consequences were underpredicted.

As compared to other site facilities, SRS tritium facilities will experience the largest percentage increase in the calculated radiological dose from the implementation of the revised dispersion parameters. The calculated radiological dose consequences for accident scenarios at TEF will increase by a factor of ~7.4 for the collocated worker and ~3.5 for the maximally-exposed offsite individual [2]. As a result, hazard scenarios currently reported to have a consequence to the collocated worker of "moderate" (i.e., between 25 and 100 rem total effective dose [TED]), or even "low," could increase to "high" (i.e., greater than 100 rem TED) when the updated dispersion parameters are implemented, assuming other input assumptions remain constant.

DOE directives and SRNS site-specific procedures require making a determination on whether SS controls are warranted when the radiological dose consequence to the collocated worker is "high." *Consolidated Hazard Analysis Process Program and Methods*, Revision 12 [4] states, "Events whose risk exceeds the Offsite, [collocated worker], and [facility worker] DOE evaluation criteria, requires mitigated hazard analysis to determine if the Safety Class and/or Safety Significant controls are adequate to bring the risk below the DOE threshold limits …." Accordingly, for accident scenarios with unmitigated consequences currently categorized as "moderate," additional controls may be needed to protect the collocated worker. For accident scenarios with unmitigated consequences categorized as "high" that are mitigated to "moderate" in the current control set, an evaluation may be needed to determine if the current control set is adequate to protect the collocated worker and sufficiently reduce the radiological dose consequences. Table 1 (see Attachment) details the hazard scenarios from the *TEF Consolidated Hazard Analysis* [5] that list either an unmitigated or mitigated radiological dose consequence to the collocated worker as "moderate." Primarily due to the distance from the site boundary, the radiological dose consequence to the public from accidents currently documented in the TEF safety basis will not exceed the evaluation guideline of 25 rem TED when the updated dispersion parameters are implemented. Therefore, consequences to the public are not presented in Table 1.

Path Forward—SRNS personnel acknowledged that additional controls may be needed to protect the collocated worker when the updated atmospheric dispersion parameters are implemented. Therefore, SRNS plans to reanalyze all of the hazard and accident analyses, in addition to incorporating the updated dispersion parameters, as part of an upcoming TEF safety basis update.

TEF FSS Water Supply. The TEF FSS is a wet pipe system credited as SS to reduce the likelihood that small fires will develop into full facility fires within the tritium processing areas of TEF. To perform this safety function, site personnel determined that one fire water supply tank needs to be in service (i.e., 902-1H or 902-2H) with a minimum of 250,000 gallons of water available. The fire water supply tank and associated FSS support systems, including pumps, located outside the facility boundary are not credited as SS. Currently, the *Memorandum of Understanding Between Infrastructure Services and Savannah River Tritium Enterprise for Fire Water Supply Systems Owned and Operated by Site Infrastructure* [6] addresses the requirements to assure the availability of the fire water supply. For example, the Memorandum of Understanding requires the SRS Operations Center to notify Infrastructure Services upon activation of a low-level alarm in the water supply tanks, and then for Infrastructure Services to notify the TEF Shift Operations Manager (SOM). When notified that the water level of the in-service supply tank has dropped below 250,000 gallons, the SOM is required to establish an immediate fire patrol. Currently, no remote monitoring exists that allows the SOM to verify the water supply capability from within the tritium control rooms. The Board's staff team believes that remote monitoring of the water supply capability, including water tank level, in the tritium control rooms would provide a more direct means of alerting the SOM of water supply issues that impact the FSS. In addition, remote monitoring would reduce the opportunity for miscommunication or delays in alerting TEF personnel. In accordance with the intent of DOE Order 420.1B, *Facility Safety*, the staff team believes that crediting the fire water supply and associated FSS support systems as SS would provide the highest level of confidence in the ability of the FSS to perform its safety function. However, the staff team acknowledges that improvements to the TEF water supply tank monitoring capabilities are a first step toward providing adequate assurance of the water supply.

Path Forward—SRNS personnel are in the preliminary stages of developing a wireless tank level monitor that would provide direct information to the tritium control rooms; however, SRNS plans to continue to rely on Infrastructure Services notifications for the foreseeable future. The staff team believes that SRNS personnel should consider crediting the wireless tank level monitor as SS once it is installed. This approach is consistent with DOE Standard 1066-2012, *Fire Protection*, which states, "The support systems shall be classified as equal or superior to the classified wet pipe sprinkler system, if they are essential to the sprinkler system performing its safety function." An SS remote monitor would alert TEF when the available fire water supply is insufficient to support the FSS's credited safety function. The Savannah River National Laboratory FSS provides a model for implementing such a change, since the safety basis at the laboratory [7, 8] credits an SS remote monitor, requires surveillances for performing functional tests of the monitor, and includes periodic verification of the tank level.

SMPs and Administrative Controls. The TEF safety basis credits SMPs and administrative controls to perform SS functions for specific accident risk reductions as part of its approved control set. This approach is inconsistent with DOE Standard 1186-2004, which states that an administrative control shall be classified as a SAC if it "is identified in the DSA [Documented Safety Analysis] as a control needed to prevent or mitigate an accident scenario, and … has a safety function that would be safety-significant or safety class if the function were provided by an SSC [structure, system, or component]." DOE Standard 3009-1994, Change Notice No. 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, states that "programmatic controls should not be used to provide

preventive or mitigative functions for accident scenarios identified in the safety basis where the safety function has importance similar to, or the same as, the safety function of safety-class or safety-significant SSCs. The classification of SAC was specifically created for this safety function." Additionally, DOE Standard 1186-2004 clarifies the role of SMPs as follows: "The cumulative effect of [SMPs] is recognized as being important to overall facility safety, as opposed to specific accident risk reduction." An independent assessment performed by the National Nuclear Security Administration's Office of Infrastructure and Operations (NA-00 at the time, now part of NA-50) [9] also identified instances where SMPs were the only credited control.

Path Forward—SRNS has a Corrective Action Plan to eliminate crediting SMPs and administrative controls for risk reduction in the safety basis. This effort will be completed as part of an upcoming TEF safety basis update.

Additional Observations. In addition to the safety issues listed above, the Board's staff team noted the following observations:

Asphyxiation Hazards Identified as Standard Industrial Hazards—Due to the small free volume in many rooms within TEF, failure of the inert gas (i.e., nitrogen and argon) transfer piping can result in asphyxiation hazards for the facility worker. For example, failure of inert gas transfer piping in the HVAC Equipment Room (Room 122) within the Tritium Processing Building (TPB) would reduce the room oxygen concentration to levels that could potentially result in loss of consciousness, or even death, within minutes [10, 11]. Due to these concerns, SRNS personnel installed restrictive orifices to limit the gas flow within the transfer piping, such that failure of the piping would not result in an asphyxiation hazard (i.e., room oxygen concentrations below 19.5 percent). Within the *TEF Consolidated Hazard Analysis*, assumption 63 states, "According to M-CLC-H-02447, *TEF Asphyxiation Calculation* … when the recommended restrictive orifices are installed then the asphyxiation hazard no longer exists in TPB or RHB [Remote Handling Building]. These orifices were installed in accordance with [Commercial Light Water Reactor] pipe and instrument designs … therefore asphyxiation due to leaks of nitrogen or argon is not credible" [5].

Treating this asphyxiation hazard as a standard industrial hazard without considering the need for SS controls is inconsistent with both site procedures and current DOE Directives. Attachment 8.5, *Safety Item Selection Precedence*, within SRNS Manual E7, Procedure 2.25 – Revision 20, *Conduct of Engineering and Technical Support Procedure Manual: Functional Classifications*, states, "As described in DOE Standard 1189-2008, *Integration of Safety into the Design Process*, Appendix C… SSCs that are covered under [SMPs applied for facility worker risk reduction] do not require specific classification as SS, but may be covered as part of the SMP. However, some conditions warrant consideration of SS SSCs. These include … [l]eaks from process systems where asphyxiation of a Facility Worker normally present may result" [12]. Further, while not yet adopted by SRNS, DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, clarifies this scenario: "Examples of conditions that warrant consideration of SS designation include … [u]nique hazards that could result in asphyxiation or significant chemical/thermal burns."

Calculations with Non-Conservative Assumptions—The Board's staff team identified several calculations supporting the TEF safety basis that contained parameters that were neither conservative nor technically justified, including calculations related to hydrogen generation and hydrogen explosions. SRNS personnel have taken actions to correct the calculations.

Attachment

Table 1: Hazard Analyses from the *Tritium Extraction Facility Consolidated Hazard Analysis* [5]				
Scenario[1]	Description	Collocated Worker (WG3) Radiological Consequences		WG3 Credited Mitigative Controls[2,3]
		Unmitigated	Mitigated	
RHB-1-003	Fire in one or more rooms results in the release of radioactive material	High (H)	Moderate (M)	(Safety-significant [SS]) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
RHB-2-004	Explosion in glovebox 1 uranium bed results in release of tritium and uranium (depleted)	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
RHB-2-006	Explosion in the process (i.e., tanks, lines, vessels) due to oxygen introduction from external process connections results in the release of tritium	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
RHB-3-002	Loss of confinement of the furnaces in the Remote Handling Area results in release of radioactive material	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
RHB-3-003	Loss of primary and secondary confinement from piping, tanks, and beds (including process piping and stripper header outside the glovebox) associated with gloveboxes 1 and 500 results in release of radioactive material	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]

[1] The hazard scenarios listed occur in the following locations: Remote Handling Building (RHB), transfer line (TL), Tritium Process Building (TPB), and Waste Storage Area (WSA).
[2] The list of controls does not include credited preventive or mitigative controls that affect only facility workers (WG1 and WG2) (i.e., only credited mitigative controls that affect WG3 are listed).
[3] The mitigated frequencies for the hazard scenarios listed range from "extremely unlikely" to "anticipated."

Attachment (continued)

Scenario	Description	Radiological Collocated Worker (WG3) Consequences		WG3 Credited Mitigative Controls
		Unmitigated	Mitigated	
RHB-6-002	Aircraft crash results in release of tritium, with and without fire	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
TL-3-001	Breach in the underground transfer line between TEF and 233-H results in release of tritium	H	M	(SS) Transfer Line Jacket (Provides secondary confinement) [Transfer line jacket confines any releases from primary piping]
TPB-2-004	Explosion in the process (i.e., tanks, lines, vessels) due to oxygen introduction from external process connections results in the release of tritium	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
TPB-3-004	Loss of primary and secondary confinement from piping, tanks, and beds (including process piping and stripper headers outside of gloveboxes including the overhead) results in release of tritium	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
TPB-6-001	Aircraft crash results in release of tritium, with or without fire	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
TPB-7-001	Seismic event causes fire that results in release of tritium	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
TPB-7-002	Seismic event causes loss of confinement that results in release of tritium	H	M	(SS) Emergency Preparedness Program (Personnel sheltering and/or evacuation) [Limits exposure to released material]
WSA-1-001	Fire in WSA results in release of radioactive material	M	None	None [Only controls listed mitigate WG1 and WG2]

Attachment (continued)

Scenario	Description	Radiological Collocated Worker (WG3) Consequences		WG3 Credited Mitigative Controls
		Unmitigated	Mitigated	
WSA-3-003	Loss of confinement in WSA during material handling activities, excluding waste container opening, results in release of radioactive material	M	M	None [Only controls listed mitigate WG1 and WG2]

Cited References

[1] Savannah River Nuclear Solutions, *Tritium Extraction Facility Safety Analysis Report*, WSRC-SA-1-2-VOL-4, Revision 8, Aiken, SC, December 2013.

[2] Vincent, A. M., *Dispersion Modeling Project Implementation*, S-ESR-G-00033-Rev.0, Savannah River Nuclear Solutions, Aiken, SC, October 2013.

[3] United States Environmental Protection Agency, *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, Research Triangle Park, NC, February 2000.

[4] Savannah River Nuclear Solutions, *Consolidated Hazard Analysis Process (CHAP) Program and Methods Manual*, SCD-11, Revision 12, Aiken, SC, March 2014.

[5] Savannah River Nuclear Solutions, *Tritium Extraction Facility Consolidated Hazard Analysis (U)*, SRNS-TR-2009-00073, Revision 4, Aiken, SC, October 2013.

[6] Savannah River Nuclear Solutions, *Memorandum of Understanding Between Infrastructure Services and Savannah River Tritium Enterprise for Fire Water Supply Systems Owned and Operated by Site Infrastructure*, DPD-TPD-99-0047, Revision 12, Aiken, SC, October 2014.

[7] Savannah River Nuclear Solutions, *Justification for Continued Operations for Issues with Backfit Analysis of the A&M-Area Outside Underground Fire Water Supply System and the Building 733-A Sprinkler Systems*, U-JCO-A-00002, Revision 2, Aiken, SC, October 2014.

[8] Savannah River Nuclear Solutions, *Savannah River National Laboratory Technical Area Nuclear Facilities Documented Safety Analysis*, U-DSA-A-00001, Revision 0, Aiken, SC, May 2015.

[9] National Nuclear Security Administration, *Assessment Report for the Limited Safety Basis Review at the Savannah River Tritium Facilities*, Aiken, SC, April 2014.

[10] Savannah River Nuclear Solutions, *TEF Asphyxiation Calculation*, M-CLC-H-02447, Revision 8, Aiken, SC, April 2006.

[11] United States Chemical Safety and Hazard Investigation Board, *Hazards of Nitrogen Asphyxiation*, Safety Bulletin No. 2003-10-B, Washington, DC, June 2003.

[12] Savannah River Nuclear Solutions, *Conduct of Engineering and Technical Support Procedure Manual: Functional Classifications*, E7 Manual Procedure 2.25, Aiken, SC, November 7, 2012.