DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

May 16, 2011

The Honorable Thomas P. D'Agostino
Administrator
National Nuclear Security Administration
U. S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Mr. D'Agostino:

The staff of the Defense Nuclear Facilities Safety Board (Board) conducted a review of the safety basis and control strategy for the Tritium Facility at Lawrence Livermore National Laboratory (LLNL). The results of this review indicated that the proposed control strategy outlined in the newly revised safety basis does not align with the Department of Energy's (DOE) clearly defined hierarchy of controls for ensuring worker safety. The Board believes that the proposed strategy provides neither adequate credited safety controls for certain postulated fire scenarios involving tritium nor an appropriately credited confinement strategy.

Since an initial staff review in September 2009, LLNL has revised the safety basis for the Tritium Facility and proposed a new control strategy. The new strategy involves downgrading gloveboxes from their current safety-significant status and relying instead on a safety-significant room alarm to alert workers to tritium releases. Further, the new control strategy and proposed path forward eliminates reliability enhancements to the fire detection and alarm system implemented under a Justification for Continuing Operation (JCO), and relies on emergency preparedness protocols in lieu of formally credited safety controls to address fire scenarios. The proposed revision to the safety basis represents a relaxation of the existing safety posture of the facility and current JCO by relying on administrative controls instead of engineered features to provide protection for workers. This strategy is inconsistent with DOE Standard 3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses,* which prescribes a hierarchy of controls, consistent with sound engineering practices, in which safety structures, systems, and components (SSCs) are preferred over administrative controls.

Therefore, pursuant to 42 U.S.C. § 2286b(d), the Board requests a report and briefing within 30 days of receipt of this letter providing the rationale for the current proposed control strategy and safety basis for the Tritium Facility at LLNL.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Mrs. Mari-Jo Campagnone

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

March 29, 2011

MEMORANDUM FOR: T. J. Dwyer, Technical Director

COPIES: Board Members

FROM: J. L. Shackelford

SUBJECT: Review of Safety Basis for Tritium Facility, Lawrence Livermore National Laboratory

This report documents the results of a review by the staff of the Defense Nuclear Facilities Safety Board (Board) of the safety basis and hazard controls associated with the Tritium Facility, including the Tritium Processing Station (TPS), at Lawrence Livermore National Laboratory (LLNL). The staff's review efforts spanned the period from September 2009 through February 2011 and were conducted by staff members J. Anderson, Z. Beauvais, M. Dunlevy, E. Gibson, J. Plaue, and J. Shackelford.

Staff Review Efforts and Related Board Correspondence. The staff conducted a site visit and developed a number of initial observations related to the safety strategy for the TPS in September 2009. Following this initial review, the Board issued a letter, dated January 27, 2010, documenting a number of issues regarding the safety basis and control strategy for the TPS. Since its September 2009 site visit, the staff has been closely following LLNL's efforts to address the issues identified in that letter. The staff recently conducted an additional site review and video-teleconference to obtain further information related to the disposition of those issues.

In response to the Board's January 2010 letter, LLNL proposed, and the Livermore Site Office (LSO) approved, an interim Justification for Continuing Operation (JCO) that implemented a number of compensatory measures to improve the safety posture of the Tritium Facility. These measures included additional actions to ensure the reliability and availability of the fire detection and alarm system to mitigate the dose consequences of certain postulated fire scenarios, as well as the reliability and availability of tritium room monitors to mitigate the dose from certain loss-of-confinement scenarios. The Department of Energy (DOE) reported these actions in a letter to the Board dated March 24, 2010. It is important to note that at the time of the staff's initial review, all gloveboxes containing more than 600 curies (Ci) of tritium were formally credited as safety-significant confinement boundaries.

Subsequent to issuing and implementing the JCO, LLNL revised the 2008 safety basis for the Tritium Facility and submitted the revised analysis to LSO for review and approval. The

staff's review of the revised analysis raised a number of additional issues regarding the selection of controls for certain postulated tritium release and fire scenarios.

Confinement Safety Classification. The safety basis approved in 2008 designates the glovebox systems for tritium quantities in excess of 600 Ci as safety-significant to provide a passive barrier for worker protection. In the recently submitted safety basis update, however, LLNL proposed downgrading the gloveboxes to an internally defined defense-in-depth "equipment important to safety" (EITS) classification. EITS is not a formally defined safety classification in the context of a safe harbor hazard analysis compliant with Title 10 Code of Federal Regulations (CFR) Part 830, *Nuclear Safety Management.*

Under the proposed safety basis, tritium gloveboxes such as the TPS may contain a maximum inventory of 30 grams (approximately 290,000 curies) of tritium. This limit is important as it represents a demarcation between Hazard Category (HC)-2 and HC-3 facilities for purposes of formal hazard categorization and analysis. The Tritium Facility has been designated as a HC-3 nuclear facility.

LLNL determined that a facility worker could experience a "high"-consequence event (defined by LSO as a radiological exposure in excess of 100 rem) from certain leak scenarios involving 30 grams of relatively low-quality, partially oxidized tritium (e.g., revised safety basis events TH-13, TGO-5, and TGO-9). The staff believes these consequences warrant having a safety-significant confinement boundary (either the glovebox itself or the internal process piping and equipment) for worker protection. The revised Documented Safety Analysis (DSA) states that, as a defense-in-depth EITS control, the tritium gloveboxes provide "...a passive barrier that protects workers in the room." However, this control is not formally identified as a credited safety control. As a result, the glovebox does not have operability requirements or the quality assurance, configuration management, and maintenance benefits afforded to a safety-significant system.

In calculation AB-B331-10-008, *Estimating Local Worker Consequences from a Tritium Release*, LLNL calculated the consequences from a 30 gram release of high-quality (very low oxidation) tritium to be approximately 10 rem TED (total effective dose) to a worker in the room containing the glovebox. This calculation used a tritium oxide fraction of 0.05 percent; this value is contrary to the calculation's cited reference,[1] which recommends an overall time-independent tritium oxide conversion rate of 1.0 percent for confined releases. If the recommended value of tritium oxide were used, the dose to a worker in the glovebox room could approach 200 rad for a 10 minute exposure, and the hazard analysis would include significantly more events with "high" worker consequences and frequencies in the "anticipated" range.

In its calculation, LLNL also assumed that the leaked tritium would be instantly and uniformly distributed throughout the volume of the room (~286,000 liters). The assumption of a fully equilibrated release, although common in these types of calculations, is not always the most conservative assumption. Allowing for the possibility of more concentrated releases to the

[1] Mishima, J., and C. M. Steele, *Oxidation of Tritium Gas under Accident and Transport Conditions*, Los Alamos National Laboratory, Los Alamos, NM, LA-UR-02-3803, June 28, 2002, p. 61.

involved worker (i.e., the worker actively involved in manipulating process controls in the vicinity of a postulated leak) and/or variations in the oxide fraction could drive the dose consequences significantly higher. Given the assumption-dependent nature of the analysis, it is both reasonable and appropriately conservative to postulate a higher dose to the facility workers. In fact, DOE's approved hazard analysis methodology, as specified in DOE Standard 3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, specifically discourages reliance on quantitative estimates of localized worker dose for these types of scenarios because of the uncertainties involved.

Instead of crediting the existing passive confinement boundary, the proposed control strategy relies on a safety-significant room alarm to alert operators to tritium leaks. The operators are then assumed to evacuate before receiving any significant radiological dose. This amounts to a de facto administrative control as the primary means of protecting the facility workers. Further, it is unclear whether such an alarm function would be fully effective in protecting the involved worker, who could be subjected to a larger acute dose in the immediate vicinity of the leak, as described above.

LSO and LLNL assert that this proposed control strategy complies with DOE Standard 3009, and 10 CFR Part 830. Although current requirements do not explicitly prohibit reliance on an administrative control, DOE Standard 3009 definitively prescribes a hierarchy of controls, consistent with sound engineering practices, in which safety structures, systems, and components (SSCs) are preferred over administrative controls. Further, the hierarchy clearly gives preference to preventive (versus mitigative) controls and to controls that are closest to the hazard. For high- or moderate-consequence events, LLNL's own procedures require considering SSCs for safety-significant designation. The designation of a safety-significant, passive, engineered confinement boundary to contain radiological hazards is clearly preferred as a control strategy over the sole reliance on an active alarm function and worker egress. A conservative safety strategy might consider identifying both a safety-significant preventative and a mitigative control (e.g., the system boundary and tritium room alarm).

Building 331 Fire Suppression System. The Tritium Facility is protected by ordinary hazard pipe-schedule, wet-pipe fire sprinklers that are installed and maintained in accordance with the applicable National Fire Protection Association (NFPA) requirements. The system is currently classified as EITS. As noted earlier, EITS is not a formally recognized safety classification in the context of 10 CFR Part 830 or its associated safe harbor analysis methods. Furthermore, DOE Guide 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830*, specifically warns against the practice of "minimizing the number of safety significant SSCs...beyond what would be prudent." The revised safety basis for the Tritium Facility proposes retaining the current EITS classification for the fire suppression system. The JCO that was implemented in response to the issues outlined in the Board's January 2010 letter required a compensatory measure that would ensure the availability of a fire detection and alarm system in the B331 Radioactive Materials Area by elevating this requirement to a Technical Safety Requirement (TSR) Specific Administrative Control (SAC). The revised safety basis does not propose identifying the compensatory measures specified in the JCO as formal safety controls.

Both the existing safety basis and the proposed revision acknowledge that tritium fires will result in high consequences to the facility workers. In particular: "Specific numerical calculations of fire-related doses to the facility worker are not considered realistic. It is simply assumed that high consequences are possible if a worker can remain in the release area when a significant release occurs." As a result, the analysis assesses a number of scenarios qualitatively, including room fires and fires that breach tritium storage vessels in the building corridors, and determines that they will result in "high" worker consequences.

LLNL has chosen to not designate the fire detection or suppression systems as credited safety controls contrary to their analysis results which indicate the need for a safety-significant control. Rather, the proposed strategy relies on emergency preparedness protocols to address postulated fire scenarios. Fire suppression systems keep fires small, limiting the heat output and therefore limiting the amount of tritium evolved from beds during a fire scenario. The justification for LLNL's strategy is based on the posture that a significant fire will seriously injure the workers before it can cause a significant radiological release that might place the worker at risk. However, without a credited fire suppression system there are no controls in place to limit the fraction of the tritium inventory released in a fire scenario and the resulting potential radiological consequences.

The staff believes the proposed strategy fails to meet the safe harbor expectations and requirements, which indicate the need for a credited safety control to protect workers from high radiological consequences. A robust control strategy would incorporate the reliability, availability, and testing requirements of the relevant NFPA codes into a formal TSR-level control (commensurate with the guidance resulting from Recommendation 2008-1) to ensure the ability of the fire suppression system, and its associated support systems, to fulfill the safety function.

Additional Observations. The staff has the following additional observations:

- Natural gas is plumbed directly into the Tritium Facility in two locations, including a mechanical room adjacent to the TPS room. The hazard analysis identifies a natural gas explosion and the resulting fire as having a worker consequence of "low" and a frequency of "extremely unlikely." However, the Board's staff contends that classifying the consequence of this event as "high" is not only consistent with the classification for other fires in the facility, but also accounts for the possibility that the consequence of the natural gas explosion itself might be high. Furthermore, the frequency identified for this event is inconsistent with that for a similar event postulated for the Plutonium Facility, which is identified as "unlikely." If the worker consequence identified for this event were "high" with a frequency of "unlikely," a safety-significant control would be expected in the Tritium Facility.

- Analysts who developed both the Emergency Preparedness Hazard Assessment and the authorization basis calculation in support of the DSA hazard assessment (HC/AB-B331-0301) quantitatively calculated the consequences to collocated workers using the HotSpot® health physics code. However, the assumptions and input parameters

used in each dispersion calculation are inconsistent and can significantly impact the estimated consequences. These parameters include deposition velocities, effective wind speeds, terrain types, receptor heights, and the effect of buoyant plume rise for fire scenarios. The Board's staff understands that both calculations serve different purposes; however, this should not impact the use of fundamental dispersion parameters.

- The hazard analysis reports a "high" worker consequence resulting from a glovebox deflagration event involving 30 grams of tritium. As a result, the DSA identifies the need for a SAC to limit total hydrogen in the glovebox. The SAC limit is set to the lower flammability limit (4 percent of the glovebox volume) for hydrogen. The staff believes this limit provides insufficient margin to prevent partial-volume deflagrations. Adherence to the most relevant standard for this application, NFPA 69, *Standard on Explosion Prevention Systems*, would result in prescribing a SAC limit of 1 percent hydrogen for this scenario. NFPA 69 also supports an approach to inert the glovebox atmosphere to prevent a deflagration, which is commonly used at other facilities with tritium gloveboxes.

- The safety-significant tritium room monitor is connected to a general-service uninterruptible power supply (UPS). Upon loss of normal power, the tritium monitor control chassis will alarm, indicating low flow. The low-flow alarm is triggered by a loss of power to the ionization chamber pump that is connected only to normal building power. However, it is unclear how workers would be notified of a loss of power to the tritium room monitor in the event of a UPS failure.

Summary. In the revised safety basis, LLNL proposes downgrading gloveboxes from safety-significant to defense-in-depth EITS. The staff notes that such a designation is not formally defined in the context of existing safe harbor analyses. Further, even though a number of postulated tritium release scenarios result in "high" consequences to the facility workers, the new safety basis proposes no safety-related engineered confinement boundary as would be called for by DOE's clearly defined preferred hierarchy of controls. Rather, the proposed control strategy relies on a safety-significant tritium room alarm and operator actions to evacuate workers for accidents of consequence. In addition, the proposed safety basis does not recognize the need for a safety-significant fire suppression system to protect facility workers from the dose consequences from fires involving tritium. Overall, the staff believes that the proposed revision to the safety basis represents a relaxation of the safety posture afforded by the existing safety basis and the current JCO.