DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

August 19, 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:

Over the past two decades, the Defense Nuclear Facilities Safety Board (Board) has reviewed the design, construction, and safety basis development of major tritium facilities at the Savannah River Site (SRS). Based on these reviews, the Board was satisfied that the safety basis for these facilities was sound, and a comprehensive set of safety-related controls provided adequate protection of both the public and workers. However, results of a recent review by the Board's staff indicate that the National Nuclear Security Administration's Savannah River Site Office has approved downgrading safety controls based on changes in the safety philosophy for these facilities and in the analytical approach to calculate dose consequences to the public. The Board believes these changes have weakened the safety posture, reduced the safety margin, and increased the potential for both the workers and the public to be exposed to higher consequences. The enclosure to this letter summarizes the following specific issues identified by the Board's staff.

The revised safety basis calculations replace conservative plume dispersion parameters for accidental tritium release with less conservative parameters that may not be applicable to conditions at SRS. The dry deposition velocity for tritium oxide (0.5 cm/s) recommended for use in the *MACCS2 Computer Code Application Guidance for Documented Safety Analysis Final Report* and used in the consequence analysis for the tritium facilities does not yield the bounding consequence. By using these non-bounding, less conservative parameters, the dose to the public is underestimated.

The shift in safety philosophy replaces several safety-related preventative controls with mitigative or administrative controls. The current safety strategy relies mainly on the Emergency Preparedness program to protect collocated workers. For this program to be effective, the facility and area emergency coordinators need to be able to coordinate and communicate protective actions to the workforce. The facility and co-located workers must also be able to rapidly evacuate or shelter in an intact building. The effectiveness of this program has not been demonstrated.

The most significant issue is the lack of adequate conservatism in the revised consequence analysis for the design basis accident at the SRS tritium facilities. The results of this consequence analysis may approach or exceed the Evaluation Guideline, depending on the analytical method and input parameters used, which could necessitate safety-class controls. The Board is aware that emerging information concerning the use of surface roughness in dispersion calculations may further impact the consequence analysis.

Therefore, pursuant to 42 U.S.C. § 2286b(d), the Board requests a report and briefing within 90 days of receipt of this letter describing any plans to address the issues listed above and outlining corrective actions to be taken to address the deficiencies detailed in the enclosed report.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Mr. Glenn S. Podonsky
Mr. Douglas J. Dearolph
Ms. Mari-Jo Campagnone

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

March 17, 2011

MEMORANDUM FOR: T. J. Dwyer, Technical Director

COPIES: Board Members

FROM: T. Spatz and M. Dunlevy

SUBJECT: Review of Safety Basis, Tritium Facilities, Savannah River Site

This report documents a review by the staff of the Defense Nuclear Facilities Safety Board (Board) of the safety basis for the tritium facilities at the Savannah River Site (SRS). Staff members performed an on-site review during the week of August 23, 2010, and followed up with conference calls on September 30, 2010, and December 16, 2010, to discuss the analytical methodologies used in the safety basis. Participating members of the Board's staff included T. Spatz, F. Bamdad, D. Burnfield, M. Dunlevy, D. Gutowski, M. Moury, and M. Sautman.

Background. Several times during the past two decades, the Board has reviewed the design, construction, and safety basis development of major tritium facilities at SRS. Based on these reviews, the Board was satisfied that the safety basis for these facilities was sound, and that a comprehensive set of safety-related controls provided adequate protection of both the public and workers. However, results of a recent review by the Board's staff indicate that the National Nuclear Security Administration's (NNSA) Savannah River Site Office (SRSO) has approved downgrading safety controls based on changes in the analytical methodology and safety philosophy. These changes have weakened the safety posture of the tritium facilities. The revised safety basis may not adequately identify the set of safety-related controls necessary to protect both the public and workers because of its use of non-conservative parameters and heavy reliance on the Emergency Preparedness (EP) program. More specifically:

- The revised safety basis calculations replace conservative plume dispersion parameters for accidental tritium release with less conservative parameters that may not be applicable to conditions at SRS.

- The dry deposition velocity for tritium oxide (0.5 cm/s) recommended in the *MACCS2 Computer Code Application Guidance for Documented Safety Analysis Final Report* and used in the consequence analysis for the tritium facilities does not yield the bounding consequence.

- Several safety-related preventative controls have been replaced with mitigative or administrative controls.

- The new safety strategy relies on an EP program to evacuate collocated workers to an unspecified safe location following a design basis accident.

Tritium Dispersion Calculation. The most bounding accident scenario for the tritium facilities is an explosion followed by a fire that results in the dispersion of the entire tritium inventory of the vault, which is then assumed to become oxidized. The safety basis estimates the unmitigated consequence of this event at the site boundary to be about 13 rem total effective dose equivalent. The safety basis states that, since the unmitigated consequence was calculated conservatively, it does not challenge the Evaluation Guideline of 25 rem total effective dose equivalent as specified in Department of Energy (DOE) Standard 3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, and therefore, safety-class controls are unnecessary. Although some conservatism is built into this calculation, such as the amount of material at risk that gets released in the fire, the Board's staff believes the consequence analysis uses non-conservative values for parameters such as the dispersion coefficients and dry deposition velocity. As a result, the Board's staff believes the unmitigated consequence of the bounding accident may challenge the Evaluation Guideline, in which case the set of safety-related controls in the safety basis may not adequately address the hazard.

Dispersion Coefficients—In the mid-1990s, the SRS contractor developed a computer program, AXAIRQ, to estimate the consequences of a tritium release. This computer program had the ability to utilize the dispersion coefficients generated from either the Martin and Tikvart approximation of the Pasquill-Gifford diffusion curves or the dispersion coefficients developed by Briggs for open country calculations involving Gaussian plume dispersions. The contractor's subject matter experts determined that the Briggs (Open-Country) coefficients were more appropriate for characteristics and meteorological conditions at SRS and applied them in their dispersion calculations, instead of the Pasquill-Gifford (Martin-Tikvart) coefficients that were the default in the program (Simpkins, 1995; Simpkins, 1994). Subsequently, the contractor made significant revisions to the safety basis for the tritium facilities based on calculated accident consequences using the DOE-approved toolbox code for dispersion calculations, MACCS2 (MELCOR Accident Consequence Code System 2). As part of the change in dispersion calculation code, the contractor stopped using the Briggs (Open-Country) coefficients in favor of the Tadmor and Gur approximation of the Pasquill-Gifford diffusion curves, despite the fact that MACCS2 allowed using either set of dispersion coefficients.[1] The Pasquill-Gifford (Tadmor-Gur) coefficients yield significantly lower consequences than Briggs (Open-Country) coefficients. These two sets of dispersion coefficients were derived from separate experiments that are discussed below.

The Pasquill-Gifford diffusion curves are based on data collected from the Prairie Grass Experiments, which used a very limited range of conditions. These experiments were ground-

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[1] The Tadmor-Gur and the Martin-Tikvart approximations are two different empirical equations fitted to the Pasquill-Gifford diffusion curves. Similarly, the Briggs (Open-Country) coefficients used in AXAIRQ and in MACCS2 use the same sets of equations to determine the vertical dispersion, but a different set of equations to determine the lateral dispersion.

level releases over what was considered uniform terrain with a site surface roughness of 3 cm, with measurements collected at distances of less than 1 km. Both Tadmor-Gur and Martin-Tikvart developed a set of equations to approximate the Pasquill-Gifford diffusion curves and to extrapolate that data to distances greater than 1 km. (U.S. Department of Energy, 2004).

The Briggs (Open-Country) dispersion coefficients were derived based on a much wider range of conditions than the Pasquill-Gifford diffusion curves. The Briggs (Open-Country) dispersion coefficients were derived by combining the near-field data collected from the Prairie Grass Experiments with data from experiments conducted at Brookhaven National Laboratory and at Tennessee Valley Authority facilities, which collected measurements at intermediate and longer distances (extending greater than 10 km from the release point). Briggs also developed a set of dispersion coefficients based on experiments conducted in an urban environment. Briggs (Urban) coefficients are based on data from the St. Louis dispersion study, which investigated releases at both ground level and approximately 35 ft above the ground in an urban environment, with samples collected on arcs that were 800 m–16 km from the release point. Greater dispersion is observed in Briggs (Urban) experiments due to the increased mechanical turbulence from building structures and from enhanced buoyancy effects due to heating of concrete surfaces. However, the urban model may not be appropriate for a site such as SRS that consists mostly of trees between the release point and the site boundary (Hanna et al., 1982; Thoman et al., 2009; Simpkins, 1994; Venkatram, 2005).

The consequence analysis that supports the safety basis for the SRS tritium facilities states that the maximally-exposed off-site individual is located 11.54 km from the release point for the most bounding accident. As noted above, the safety basis now uses the Pasquill-Gifford (Tadmor-Gur) coefficients even though they are based on data collected less than 1 km from the release point. The Board's staff believes the Briggs (Open-Country) coefficients are more applicable to SRS dispersion calculations, as these dispersion coefficients are based on a wider range of data that was collected at a distance similar to that of the maximally-exposed off-site individual for the SRS tritium facilities.

Prior to the December 16, 2010, conference call with the Board's staff, SRS contractor personnel performed an analysis that compared the calculated consequences when using the Briggs (Open-Country), Briggs (Urban), Pasquill-Gifford (Tadmor-Gur), and Pasquill-Gifford (Martin-Tikvart) dispersion coefficients. This analysis demonstrated an increase in the consequences of more than 50 percent when using the Briggs (Open-Country) rather than the Pasquill-Gifford (Tadmor-Gur) dispersion coefficients. Thus, if the SRS contractor recalculates the dispersion results using the appropriate coefficients, the new unmitigated consequences may challenge the Evaluation Guideline, resulting in the need for safety-class controls.

Deposition Velocity— The safety basis consequence analysis uses a dry deposition velocity of 0.5 cm/sec for tritium oxide. Contractor representatives stated that using this deposition velocity value is consistent with the DOE *MACCS2 Computer Code Application Guidance for Documented Safety Analysis Final Report* (application guidance) (U.S. Department of Energy, 2004). The application guidance references a paper by Murphy (1993) to justify the 0.5 cm/s dry deposition velocity value. The Murphy reference does not recommend the use of

0.5 cm/s dry deposition velocity for tritium oxide. Instead, it cites data from two other sources for dry deposition of tritium oxide: *Tritium in the Environment*, National Council on Radiation Protection Report Number 62 (NCRP 1979), and *Transfer of Tritiated Water Vapour to and from Land Surfaces* (Garland 1979). The NCRP 1979 report provides a dry deposition velocity between 0.4 and 0.8 cm/s based on the mean residence time of tritiated water in the atmosphere (21 to 41 days). This time frame does not correspond to that for the most bounding accident scenario in the tritium facilities safety basis, which is a 3-minute pressurized release followed by a 20-minute fire. The Garland 1979 report measured tritiated water deposition velocities between 0.09 and 0.91 cm/s in bare soil. This is also not directly applicable because of the vegetation at SRS. It is not clear to the staff how the DOE application guidance determined that 0.5 cm/s was the bounding deposition velocity, given these sources of data. The Board's staff believes it should not be used as the bounding value for the SRS tritium facilities.

The Canadian Nuclear Safety Commission published a study in 2009 summarizing recent experiments that measured tritium oxide dry deposition velocities under both summer and winter conditions (Canadian Nuclear Safety Commission, 2009). This study reports deposition velocities of 0.16 to 0.3 cm/s under winter conditions and 0.2 to 0.4 cm/s under summer conditions. Accordingly, the Board's staff concludes that the appropriate tritium oxide deposition velocity value for safety basis calculations within the DOE complex should be significantly lower than 0.5 cm/s. However, it should be noted that the use of any non-zero deposition velocity value for tritium oxide is only valid if reemission (the release of tritium from vegetation and soil back into the atmosphere) is adequately accounted for. Reemission is fast, and at least one study has shown that greater than 50% of deposited tritium oxide can be reemitted during a 12 hour period (Täschner, et al., 1997).

As a point of reference, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories use dry deposition velocity values of either 0.0 or 0.1 cm/s for tritium oxide in their accident analysis calculations, which the Board's staff considers more appropriate for tritium oxide releases. Although the specific conditions that affect the deposition velocity of tritium oxide may differ from site to site, the overall conclusions remain the same: the sources of data cited in the MACCS2 application guidance do not apply to accident scenarios, and the value recommended in the application guidance does not yield the bounding consequence for the tritium facilities' design basis accidents.

Change in Safety Philosophy. The tritium facilities safety basis reviewed by the Board's staff in the 1990s relied on isolating and controlling the source of the hazard by means of safety-class structures, systems, and components (SC-SSC), administrative controls, and limiting conditions for operation (LCO). Over the years, the safety basis has been revised reflecting a change in safety philosophy; many of the previously credited controls were downgraded or eliminated in favor of mitigative and administrative controls. Examples of this practice include the downgrading of safety-class controls, such as the fire suppression system, the elimination of several LCOs, and some design features that are no longer credited, such as the 217-H fire walls and fire dampers. Although the amount of material at risk has remained relatively constant, SRS no longer takes credit for the use of these controls. These changes have weakened the safety posture and reduced the margin of safety for these facilities.

Protection of Collocated Workers. SRS relies heavily on the EP program to limit workers' exposure to released tritium for many of the design basis accidents. The unmitigated analysis for design basis accidents that involve the facility's entire inventory of material at risk indicates significant consequences to both facility workers and collocated workers. For example, the Tritium Facilities Natural Phenomena Hazard Plus Fire Accident Analysis, S-CLC-H-01139, identifies an unmitigated dose of 6,200 rem total effective dose equivalent to a collocated worker at 100 meters for fires that occur after a tornado and for seismically induced fires. Depending on actual meteorological conditions, workers elsewhere in H-Area and other nearby parts of SRS could face very significant radiological doses.

For the EP program to provide the credited dose mitigation, affected workers must be able to either a) shelter in a location with clean breathing air until the plume has passed or b) evacuate the area, assuming the wind direction and post-seismic road conditions allow a safe escape route. For a seismic event, the efficacy of sheltering will likely be impacted by the large number of nearby facilities that are not seismically qualified. Workers inside these facilities may be forced to leave them and go out in the plume if buildings collapse or are damaged by a seismic event. The efficacy of the EP program is further impacted by the current lack of integration in the planned responses to seismic events for nearby facilities. For example, the Technical Safety Requirements for H-Tank Farms require workers to go outside to operate tank purging equipment following a seismic event, which is not consistent with the need for exposed workers to either shelter in place or evacuate the area as quickly as possible. SRS has not demonstrated that the EP program can provide the credited degree of mitigation for all of the potentially affected workers.

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